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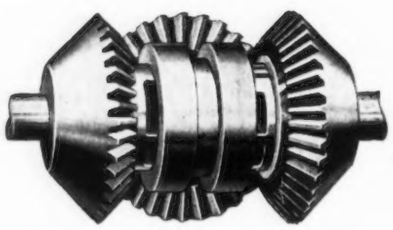

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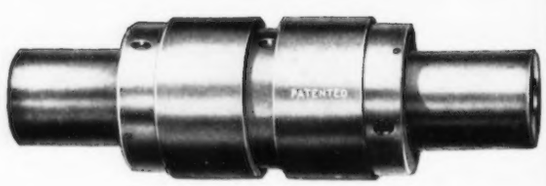

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▸ WHAT WORLD-VISIONED MINDS ◂
▸ THINK ABOUT THE WORK OF ◂
▸ THE PRODUCT ENGINEERS ◂

The Future of Electrical Entertainment —A Challenge to Product Engineers

So much is promised by the achievements of today in Radio that the greatest individual and organization resourcefulness must now be exerted to give the public what it has a right to further anticipate in the development of the entertainment arts.

Five or ten years from now, talking motion pictures will possess four elements: sound, color, motion and perspective. Into the home will come two channels for the transmission of education and entertainment; one will bring sight, the other sound. And through the work of engineers, a single outlet may serve both functions. The best in music will be offered for the ear, while for the eye will come news in the making, the vision of public events, football classics, great pictures of universal appeal. The combination of both senses, sight and sound, in talking motion pictures will make a theatre of every home.

Between this objective and the present is a chasm which the engineer will bridge. Only 11 years ago, broadcasting itself was still a dream cherished by engineers. Next they will couple the science of what they know today with what they still will learn to bring these wonders into reality. Those who are to create the apparatus and instruments for the future gifts will have their imaginations fired by the opportunities for accomplishment. The broader phases of radio progress offers a real challenge to the product development engineer.

President
Radio Corporation of America

A McGraw-Hill Publication February 1931 Volume Two, Number Two

PRODUCT ENGINEERING

The Engineer Meets the Customer

When the public set the price during 1930, the action was not taken as a "buyers' strike" but as a realization of values. 1931 will be a year of redesign and product development to meet the existing situation

DURING 1931 the product development engineer in a wide variety of industries is going to have to meet a situation that is different in its mass form from anything that industry has had to meet in this generation. Price declines have been encountered before, but usually they have been met by mass production and the improvement of manufacturing methods. The efficiency engineer had his innings just a few years ago, but the percentage of cost reduction that can be gained by further improvement of shop methods is growing less. There is still plenty to do in that direction, but the cream has been skimmed, and the savings are measured in decimal points where formerly the percentages were large. The price decline of today comes from a new angle, and to meet a new set of conditions.

Instead of designing a product, and estimating a price at which it can be marketed, or of devising new means by which an old product can be pushed more cheaply through the shops, these engineers are going to be reminded throughout the year of definite low prices at which the sales organization can sell products for specific fields, and they are going to be asked to design products that will be more efficient, more presentable, and yet salable within the price limits. Better products for less money has always been an aim, more or less indefinite, and depending greatly on the ability of the shop to cut production costs, but the present situation puts it largely up to the development engineer. He must design a better product; he must design with production in mind —parts to be made of such materials and in such ways that unit cost will be low; he must forget the old-fashioned ideas of "keeping equipment busy" if it means making parts on obsolete or slow machines just because the latter happen to be in the shop instead of in the cupola.

There is no wild prognostication in this statement. The trend is actually here, and two factors are apparent: the sharp decline in market prices originating in the consumer market and entirely out of control of the manufacturer, and the fact

that the necessary broadening of the consumer field, or field of sales, for many products, has brought an ever-increasing percentage of sales into a normally low-priced, but "fussy," market.

Sixty per cent of all household refrigerators marketed during 1930 were sold to small-salaried and wage-earner families, and they were sold at prices 11 per cent below those of the previous year. There was an enormous jump in the sales of electric clocks in 1930, but prices dropped 40 per cent below those of 1929. In 1930, also, half of all radio sales were of the "midget" type, retailing at prices below $60 complete. Topping these off comes the annual automobile show offering new precedents in better designs and "more automobile" at prices which are in some cases 20 per cent below those of last year. The immediate effect on automotive sales showed that the judgment of the designers was right.

How has the development engineer met this challenge of the sales department, and how will it all end? In the washing machine field, prices on standard types of household washers were cut practically over night from $150 and $165 to just below $100. Recently there have been further drops, bringing some prices below $80. Pressed metal parts were incorporated to supplant cast parts; die castings were used for agitators, frames, gears, and other parts; enameled steel took the place of copper shells; and in some cases the mechanisms were simplified. To meet the requirement of low price in radio, more than 80 "midgets" were placed on the market by manufacturers. Like the low-priced automobile, they are built for a price market, and they do not compete directly with the higher-priced radios. But like the low-priced automobile, also, they are required to give satisfactory service. They are not toys. The engineering was accomplished by closely-packed circuits that required less metal; economies in core materials that would not detract perceptibly from the tone although possibly shortening the life; pressed metal cases; die cast and molded parts; adoption of tubular rivets and drive screws, and of standard integral parts which eliminated soldering and connections; the incorporation of more efficient tubes, transformers, coils, and other units made in quantity by specialists.

Welding has played an important part in price reductions in many products, especially where the product was deliberately designed for welding, as in the incorporation of sheet metal. In products where castings were necessities, economies have been made by turning to more expensive alloy irons, for example, which because of better casting qualities reduced shop losses from bad castings and thus resulted in lower final costs. In some cases brass has been substituted for lower-priced steel because of more rapid machining possibilities that resulted in lower cost of finished parts. Molding of synthetic resins has also affected a vast range of

parts, often producing better jobs at less cost. At no previous time has the attention of designers been focused so closely on finishes as at present. Lacquers, enamels, japans, and electroplates are being studied and "juggled" as never before to get the desired protection or appearance at the lowest cost.

It must not be assumed, however, that the American public has gone crazy on a program of cheapness. Quality products at higher prices will still be in demand. But the evolution that took place in the automotive industry is now taking place in other lines. Out of the 34,000,000 families in the United States there are only 15,000 millionaires. If products are to be sold widely to the average working family they must offer quality at prices in keeping with the wage envelope. It has been said that American workingmen today enjoy more luxuries than kings of former years, but the time will come when it is going to be said that workmen enjoy more luxury products than the millionaires of today. If engineers can design products with appeal that can be manufactured for sale at low prices, the markets can be found.

The trend in the consumer market toward better products for less money, finer quality products, and new products that will open new markets is also having an effect on products that do not go directly to the public. A manufacturer of industrial scales has just been enabled to make tremendous savings in manufacturing costs by complete redesign of his numerous models for standardization of parts and units. This redesign has been done by the engineering department during the period of depression, and instead of "cheapening" the products, it has resulted in more accurate, more easily serviced, and better appearing products for less money. On the other hand, this same company has added to its line what might be considered as "deluxe" models that will be marketed at higher prices where the finest in appearance and workmanship is demanded.

If it were possible to draw a price-quality chart it would be found that for every unit in the product a point would be reached where it would no longer be economical to reduce cost for that particular unit. But there is no positive chart method of working out the problems involved. Product development engineers must find those economical points by knowledge of the field in each case, and where the bottom has apparently been reached with existing units, new units or a complete new product design, may have to be evolved. As an example, a cheap, unground bearing may be economical, and a high-priced bearing simply wasted in places where there are only light loads and where fine accuracy is not required, but in other machinery it may be uneconomical to use anything but the best hardened and ground bearings. To illustrate a change in method influenced by change in design, a large sheet-steel casing of a certain machine had been built up in two pressed parts and riveted together. It was redesigned in modern square lines, made in one folded piece, and seam-welded. The result was a better appearing and stiffer case at about half the price. In another case, by paying a little more money for part forgings and having them "coined" to accurate dimensions, most of the expensive machining operations were eliminated entirely and a better product was obtained because of the greater strength and wearing qualities of the forgings.

The most important function of the development engineer, therefore,

(Continued on page 76)

"I believe that the business conditions of 1930 not only will benefit the public but will be the greatest tonic industry has received in years. Easy selling produces flabby organizations . . ."
E. L. Cord, president, Auburn Automobile Company

. .

" . . . Therein is the bid of the automotive industry for expanded sales in 1931—automobiles of such outstanding qualities and at such prices that buyers cannot remain longer out of the market . . ."
G. E. Quisenberry, editor, The American Automobile

. .

And that's that from the industry that employs 10 per cent of American workers, consumes 15 per cent of American steel, 30 per cent of the aluminum, and so on!

The designer has become recognized as the vital factor in meeting the demands of the public, and in many instances in anticipating them. He is going even further in creating new markets by means of new products to serve new purposes, as well as by improvements to add sales appeal and lower costs.

The snow ball has started its roll for the greatest advances in product design that the world has known!

. .

REVERSAL OF HIGH-SPEED SPINDLES BY FRICTION CLUTCHES

By JAMES A. HALL

Professor of Mechanical Engineering Brown University, Consulting Engineer, Brown & Sharpe Manufacturing Company

TIME required for reversing clutches during engagement, the amount of slippage at the surfaces of the clutch and of the belt, energy lost in heat at each of these places, and total energy required, can be computed mathematically or determined graphically. Professor Hall presents both methods in this study based on experimental work done on high-speed automatic screw machines at the Brown & Sharpe plant

REVERSING the spindle to back off threading tools, and changing its speed for different cuts, have always played an important part in the operation of automatic screw machines. In the last few years the increase in the maximum velocity of rotation and the shortening of the time for completing each piece, have made necessary a careful study of the mechanism involved in these speed changes. One of its elements is the friction clutch which, in the past, has been considered principally from the standpoint of capacity after engagement. In high-speed spindles, however, the torque during engagement, the time required, and the energy lost in heat during slipping are of much more importance. This article presents a mathematical analysis and some of the experimental results of an investigation made by the Brown & Sharpe Manufacturing Company.

The spindle of a No. 00 automatic screw machine, mounted in its bearings, is shown in Fig. 1. The two pulleys A and B, carrying the outer members of cone clutches, usually run in opposite directions. Either may be engaged with the double-ended cone of the clutch body C, which is keyed to the spindle. The clutch body is moved along the spindle by means of lever D which is actuated by the clutch sleeve E. The spindle, driven at high speed in one direction, is engaged suddenly with the other pulley which may be going at a high speed in the opposite direction. As the clutch is much more powerful than the belt driving the pulley, the first effect is to change simultaneously the speeds of both the spindle and the pulley until they come to a common velocity and the clutch stops slipping. The belt, which is now slipping, furnishes a torque that brings both spindle and pulley up to operating speed.

In order to determine how to reduce heating and wear in these clutches, an investigation was undertaken. First, a mathematical analysis was made, and is given below. In this analysis it was assumed that the torques transmitted by the clutch and by the belt were constant during slipping.

Let I_s = Moment of inertia of spindle
I_p = Moment of inertia of pulley
ω_1 = Original velocity of the spindle in radians per sec.
ω_2 = Original velocity of the pulley in radians per sec.
ω = Velocity of spindle and pulley at point where clutch stops slipping.
T_b = Torque transmitted by belt when slipping, lb.-ft.
T_c = Torque transmitted by clutch when slipping, lb.-ft.
t_1 = Time from engagement of clutch until slipping stops, in seconds
t_2 = Time to bring spindle to full speed after clutch stops slipping.
$t = t_1 + t_2$ = total time for reversal.

In using the above velocities, due regard must be paid to whether the values are positive or negative. Taking ω_2 as positive, ω_1 will be negative in case of a reversal of the spindle.

Considering spindle alone

$$T_c t_1 = I_s (\omega - \omega_1) \qquad (1)$$

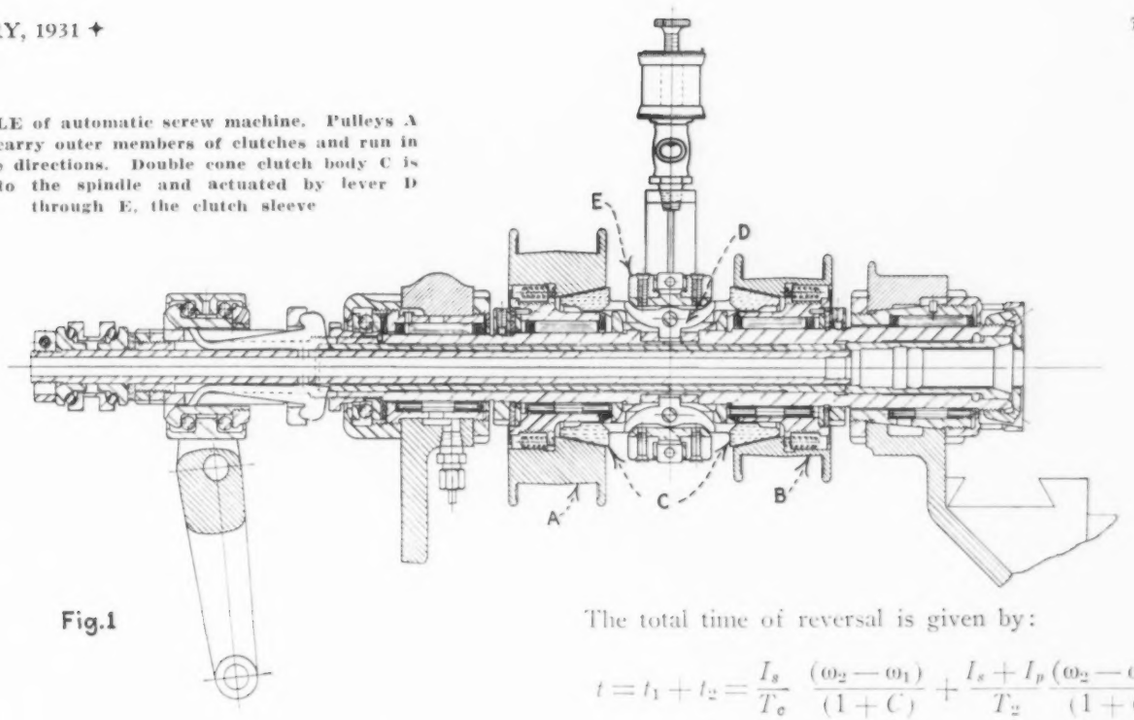
Considering pulley alone

$$(T_c - T_b)\, t_1 = I_p (\omega_2 - \omega) \qquad (2)$$

Dividing (2) by (1)

$$\frac{\omega_2 - \omega}{\omega - \omega_1} = \frac{I_s}{T_c - T_b}$$

Representing the second half of this equation by C, as it is a constant for any set of conditions,



SPINDLE of automatic screw machine. Pulleys A and B carry outer members of clutches and run in opposite directions. Double cone clutch body C is keyed to the spindle and actuated by lever D through E, the clutch sleeve

Fig.1

$$\omega_2 - \omega = C(\omega - \omega_1)$$

$$\omega = \frac{\omega_2 + C\omega_1}{1 + C} \qquad (A)$$

This is the velocity at which the clutch stops slipping. Substituting ω from equation (A) in equation (1),

$$t_1 = \frac{I_s}{T_c}\left(\frac{\omega_2 + C\omega_1}{1 + C} - \omega_1\right) = \frac{I_s}{T_c}\left(\frac{\omega_2 - \omega_1}{1 + C}\right) \qquad (B)$$

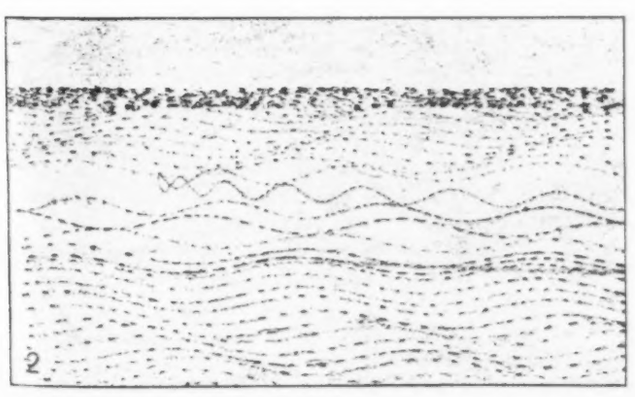
Considering clutch and pulley together after the clutch has stopped slipping.

$$T_b t_2 = (I_s + I_p)(\omega_2 - \omega) \qquad (3)$$

Substituting ω from equation (A),

$$t_2 = \frac{I_s + I_p}{T_b}\left(\omega_2 - \frac{\omega_2 + C\omega_1}{1 + C}\right)$$

$$= \frac{I_s + I_p}{T_b}\ \frac{(\omega_2 - \omega_1)C}{(1 + C)} \qquad (C)$$



GRAPHICAL RECORD of spindle reversal taken by means of a tuning fork making 176 complete vibrations per second. Spindle running initially at 3,600 r.p.m. Path starts at the top, going from right to left, reverses in the center and goes from left to right at the bottom

The total time of reversal is given by:

$$t = t_1 + t_2 = \frac{I_s}{T_c}\ \frac{(\omega_2 - \omega_1)}{(1 + C)} + \frac{I_s + I_p}{T_b}\ \frac{(\omega_2 - \omega_1)C}{(1 + C)}$$

$$t = \frac{\omega_2 - \omega_1}{(1 + C)}\left[\frac{I_s}{T_c} + \frac{I_s T_c}{T_c T_b}\left(1 + \frac{I_p}{I_s}\right)C\right]$$

Let

$$\frac{T_b}{T_c} = X, \qquad \frac{I_s}{I_p} = Y, \text{ and } C = (1 - X)Y$$

$$t = \frac{(\omega_2 - \omega_1)}{(1 + Y - XY)}\ \frac{I_s}{T_c}\left[1 + \frac{1}{X}\left(1 + \frac{1}{Y}\right)(1 - X)Y\right]$$

$$= \frac{(\omega_2 - \omega_1)}{(1 + Y - XY)}\ \frac{I_s}{T_c}\left[\frac{XY + Y^2 + Y - XY^2 - XY}{XY}\right]$$

$$= \frac{I_s}{T_c}\ \frac{(\omega_2 - \omega_1)}{X}$$

But

$$T_c X = T_b$$

Hence

$$t = \frac{I_s}{T_b}(\omega_2 - \omega_1) \qquad (D)$$

Relative velocity of the clutch and pulley at engagement is $(\omega_2 - \omega_1)$ and becomes zero when slipping ceases: therefore, the average velocity of slipping is $\frac{(\omega_2 - \omega_1)}{2}$. The time of slipping is t_1.

Distance clutch slips $= t_1 \frac{\omega_2 - \omega_1}{2} = \theta_c$ radians.

Substituting for t_1 its value given in equation B,

$$\theta_c = \tfrac{1}{2}\frac{I_s}{T_c}\ \frac{(\omega_2 - \omega_1)^2}{(1 + C)} \qquad (E)$$

The torque between the surfaces is T_c, and the work lost in friction is the product of this torque and the distance slipped.

$$\text{Energy lost at clutch} = T_c\theta_c = \tfrac{1}{2} I_s\ (1 + C) \qquad (F)$$

Velocity of the pulley during reversal varies from ω_2 to ω and back to ω_2 giving an average of $\frac{\omega_2 + \omega}{2}$.

The velocity ω_2 of the belt is considered constant.

Distance traveled during period of reversal is $\frac{\omega_2 + \omega}{2}(t_1 + t_2)$ for the pulley and $\omega_2(t_1 + t_2)$ for the belt. The slip of the belt on the pulley is the difference of these two.

$$\theta_b = (t_1 + t_2)\left(\omega_2 - \frac{\omega_2 + \omega}{2}\right) = (t_1 + t_2)\left(\frac{\omega_2 - \omega}{2}\right)$$

$$= \tfrac{1}{2}(t_1 + t_2)\left(\omega_2 - \frac{\omega_2 + C\omega_1}{1 + C}\right)$$

$$= \tfrac{1}{2}(t_1 + t_2)\frac{(\omega_2 - \omega_1)C}{(1 + C)}$$

But $$= t_1 + t_2\frac{I_s}{T_b}(\omega_2 - \omega_1)$$

Hence $$\theta_b = \tfrac{1}{2}\frac{I_s}{T_b}\frac{(\omega_2 - \omega_1)^2 C}{(1 + C)} \qquad (G)$$

Multiplying this distance slipped by the torque T_b between the surfaces, we get the energy lost in heat.

$$\text{Energy lost at belt} = \tfrac{1}{2} I_s \frac{(\omega_2 - \omega_1)^2 C}{(1 + C)} \qquad (H)$$

Adding F and H gives the total loss for each reversal.

$$\text{Total energy lost} = \tfrac{1}{2} I_s (\omega_2 - \omega_1)^2 \left(\frac{1}{1 + C} + \frac{C}{1 + C}\right)$$

$$= \tfrac{1}{2} I_s (\omega_2 - \omega_1)^2 \qquad (I)$$

The work put in by the belt during reversal is equal to the belt torque T_b times the distance it moves $\omega_2 (t_1 - t_2)$.

$$\text{Work put in by belt} = T_b \omega_2 (t_1 + t_2)$$

But $$t_1 + t_2 = \frac{I_s}{T_b}(\omega_2 - \omega_1)$$

Hence work put in by belt $= I_s \omega_2 (\omega_2 - \omega_1)$ (J)

Several of the above expressions are worthy of special notice. For instance, equation D shows that the time required for a complete reversal or for a speed change of a given amount depends only on the pull or torque supplied by the belt and the moment of inertia of the spindle, and is independent of the torque of the clutch and the moment of inertia of the pulley. This is, of course, true only when the clutch is more powerful than the belt drive.

Equation I shows that the energy lost in heat for each reversal is the product of half the moment of inertia of the spindle and the change in speed squared. It is independent of the pulley size and of the power of the clutch or of the belt. Equations F and H give the division of the energy loss between the clutch and the belt surface.

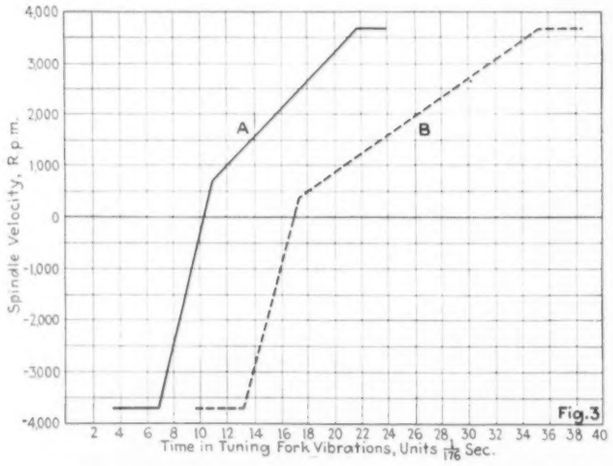
Equation J differs from I because it takes into account the final kinetic energy of the spindle. Much more energy must be supplied to change a spindle from slow speed in one direction to a high speed in the opposite direction than to reverse the process, the exact amount being proportional to the product of the change in speed and the final speed.

As the above statement is often questioned when it is first encountered, another development may be of interest. Starting with the loss in heat at the clutch and belt as given by equation I, it is apparent that during a reversal part of this heat comes from the original kinetic energy which must be dissipated from the spindle. The belt must then supply the final kinetic energy of the spindle and in addition the remainder of the above heat loss. That is, the total work put in by the belt must equal the sum of the initial and final kinetic energies plus the heat loss. This is given by the following equation, wherein ω_1 is negative, being the reverse direction.

$$\text{Work put by belt} = \tfrac{1}{2} I_s (\omega_2 - \omega_1)^2 - \tfrac{1}{2} I_s \omega_1^2 + \tfrac{1}{2} I_s \omega_2^2$$

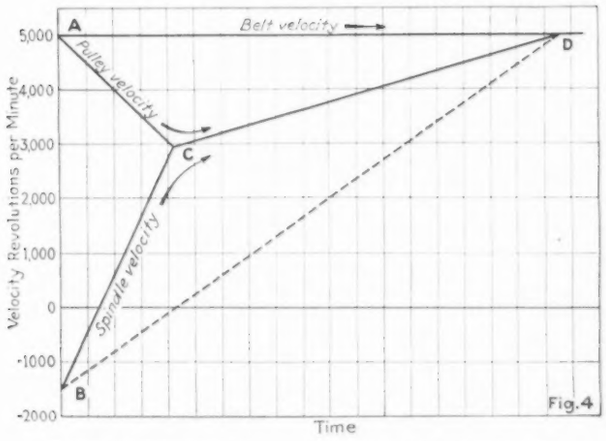
$$= I_s \omega_2 (\omega_2 - \omega_1)$$

A series of experiments was next undertaken to check the mathematical analysis, to determine actual conditions existing during clutch operation, and to compare the wearing qualities of different clutch materials. In most cases the spindle was run on a complete cycle including two reversals, over and back, of 1.1 seconds. Graphical records of reversal were made on strips of coated paper which were wrapped around a cylinder mounted in the spindle chuck. The record was made by means of a tuning fork making one hundred and seventy-six vibrations per second. Fig. 2 shows one of these records.



VELOCITY-TIME diagram plotted from measurements on tuning fork diagram converted into velocity

The velocity of the spindle at successive instants during the reversal was found by measuring the distance between the tops of adjacent waves. These measurements were converted to velocity in radians per second or in revolutions per minute. Plotting these figures vertically with time for the horizontal scale gave a velocity-time diagram and the accelerations were calculated from the slope of this line. Fig. 3 shows such a record of a No. 00 high-speed spindle reversing at 3,600 r.p.m. The line A gives the change of speed of the spindle when the clutch engages the front pulley, and B when it enters the rear pulley. While these pulleys actually run in opposite directions, the curves are both plotted with the final velocity of the spindle as positive.



TIME-VELOCITY diagram showing the changes in speed of the various members of the spindle

The points are the observations from the tuning fork diagram. It may be of interest to note that this spindle was brought from 3,600 r.p.m. to zero velocity in about one-fortieth of a second and that the complete reversal took about one-eighth of a second from the time the clutch was engaged.

These diagrams demonstrated the accuracy of the assumptions made in the mathematical analysis, namely, that the torques transmitted by the clutch and by the belt while slipping are practically constant in drives of this type. The curves were also used to determine the capacities of both the clutch and the belt under slipping conditions. The slope of the lines on the diagram gave the acceleration while the moments of inertia of the spindle and of the pulleys were determined by experiment.

This data was then used to check the formulas given in this paper. The velocity at which slipping stopped, the time for reversal, and other factors, were all found to be well within experimental error. The energy lost during reversal was also measured by use of an integrating wattmeter, the readings of which checked closely with the figures given by the formula.

While the graphical record of reversal was of value in demonstrating the accuracy of the mathematical analysis, it found even greater use in the study of clutch wear. Endurance tests were run ten hours a day for many days at a time, using a 1.1-second cycle on spindles having clutches made of different materials. Periodic tuning fork records showed exactly how much the torque of the clutch had decreased as a result of wear of the parts.

Curves plotted from the experimental data showed that the results of the mathematical work could be replaced in considerable part by a graphical analysis. Referring to Fig. 4, the spindle is assumed to be running at a velocity of 1,500 r.p.m. in a negative direction as shown at B, while the pulley is going at 5,000 r.p.m. in the positive direction, indicated by A. At the beginning of the diagram the clutch has just connected the spindle and pulley. The change in the speed of the spindle is shown by line BC while that of the pulley is given by AC. At the speed and time represented by C the clutch stops slipping, and the belt then accelerates both spindle and pulley along line CD back to its original velocity.

If the torque transmitted by the clutch and the moment of inertia of the pulley are known, the angular acceleration α is given by the equation:

$$\alpha = \frac{T_c}{I_s}$$

If the vertical scale is in radians per second the slope of the line BC is given by α. Likewise the slope of the line AC is given by the ratio of the difference between clutch and belt torque to the moment of inertia of the pulley. The slope CD is the ratio of the belt torque to the sum of the moments of inertia of the spindle and pulley.

The relative velocity of the spindle and pulley at engagement is AB and drops to zero at C. The distance the two surfaces of the clutch slip on each other is given, therefore, by the area of the triangle ABC, and can be calculated in revolutions by taking the proper units. Likewise, the distance slipped by the belt is given by the triangle ACD. The energy lost in heat is found by multiplying the torque in pound-feet by the angle through which the surfaces slip.

If the speed change could be made by a rapid shifting of belts, the clutch being omitted entirely, the spindle velocity would be given by line BD. The total time required would be the same as in the clutch and belt arrangement provided the belt capacity and spindle inertia were the same.

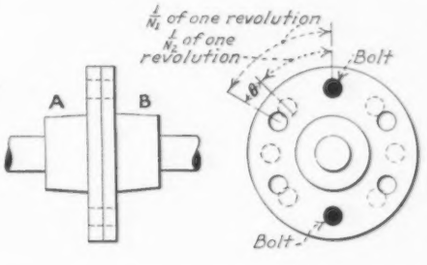
■

Positive Adjustable Coupling

By A. W. Knight
Ipswich, England

SINCE it is not capable of close adjustment, the use of an ordinary flange coupling between two shafts is not permissible if the shafts must be rotatively adjustable with respect to each other. The coupling here described, however, is capable of such adjustment.

The coupling as shown in the illustration is of ordinary flange type, except that the half-coupling A is drilled with eight bolt holes and the half B with six. The halves of the coupling are bolted together by two bolts only, and these must be capable of transmitting the load.



It is seen that two pairs of holes coincide as shown by blacked-in circles marked *"Bolt."* The holes shown dotted are in half-coupling A, and those in full lines in half-coupling B. Let the smallest fraction of a revolution through which A could be turned before another two pairs of holes would coincide, be designated as θ—

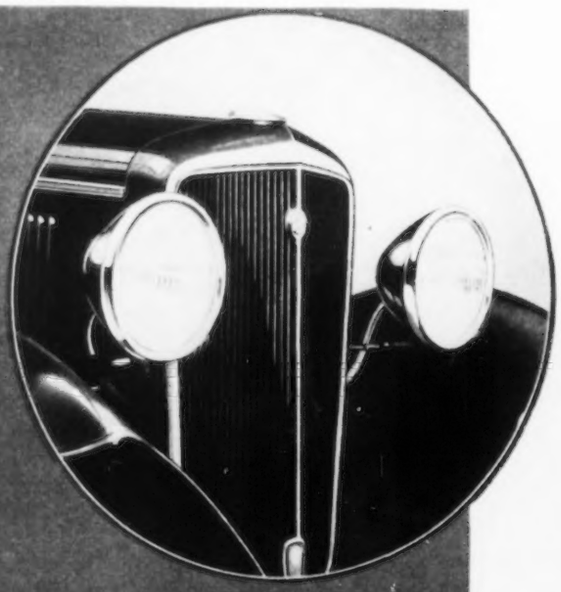
Let N_1 = number of holes in B, and N_2 = number of holes in A.

$$\text{Then } \theta = \frac{1}{N_1} - \frac{1}{N_2} = \frac{N_2 - N_1}{N_1 N_2}$$

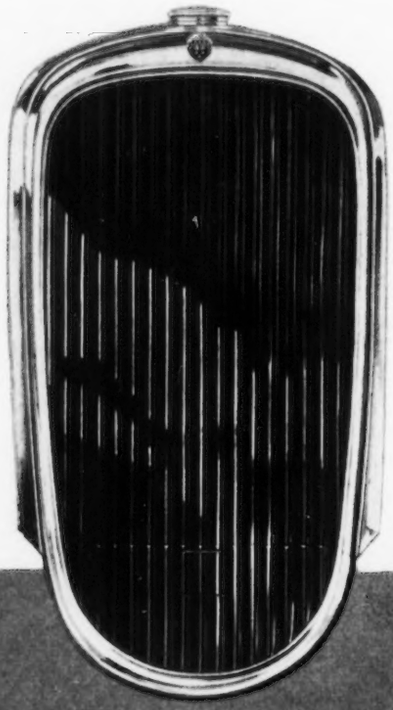
For six and eight holes,

$$\theta = \frac{8 - 6}{8 \times 6} = \frac{1}{24} \text{ revolution}$$

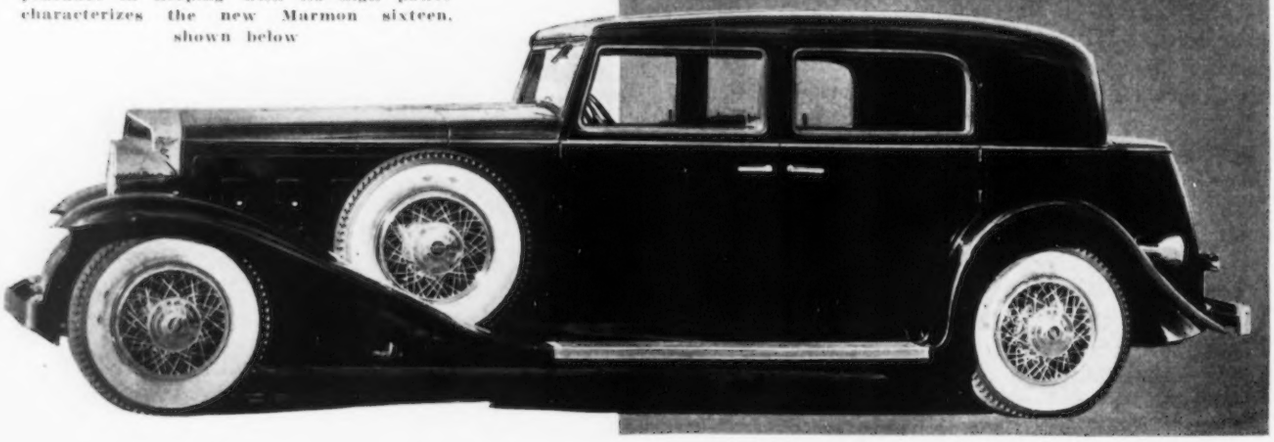
Provided that the number of holes is even, and that the holes in one half-coupling are two less than in the other, any number of holes may be used.



STUDEBAKER'S new six, at left, has a **V-type radiator and sharply in-swept fender lines, now becoming popular. The Oldsmobile radiator, shown below, is among those narrowed at the bottom in conformance with present trends**



AUBURN'S latest eight, above, presents a smart frontal appearance. Single-bar bumpers with center dip are in vogue. Massive appearance in keeping with its high power characterizes the new Marmon sixteen, shown below



1931 CARS INCORPORATE NOTEWORTHY IMPROVEMENTS

By HERBERT CHASE

Associate Editor

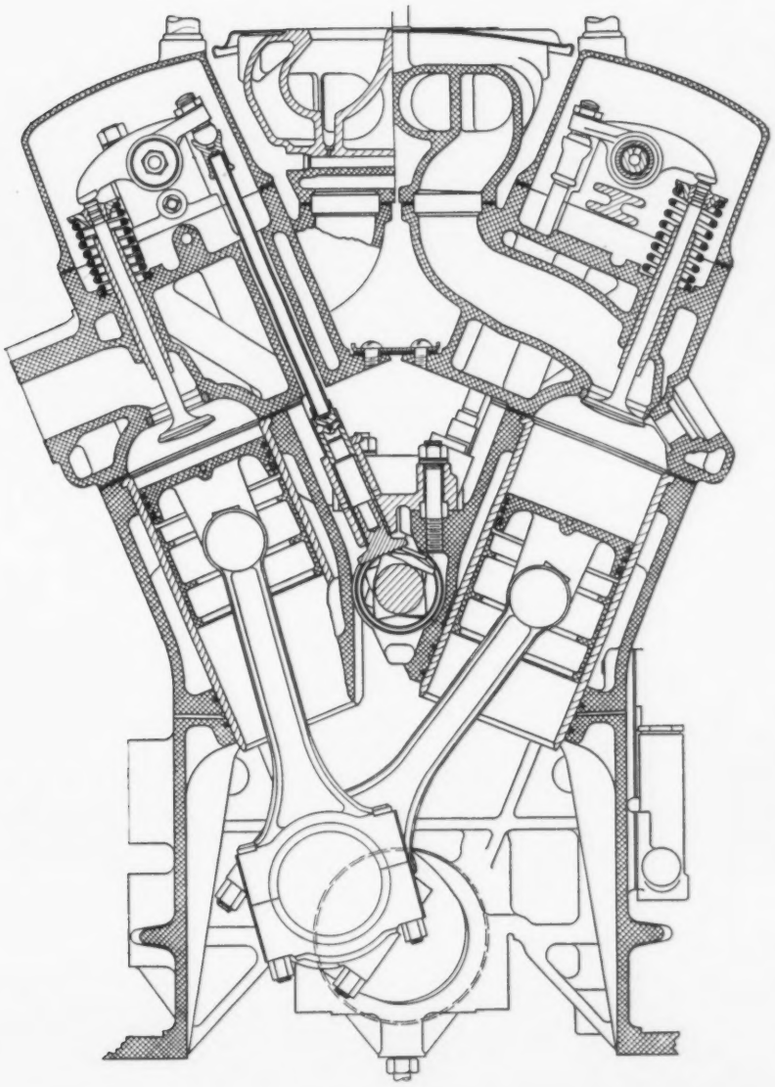
NO SINGLE major unit in 1931 automobile chassis design has undergone so great or so general improvement as the gearset. The addition of a free-wheeling unit, although found in only five makes of cars exhibited at the New York automobile show, is considered by many engineers as the outstanding development of the year. Equally important, perhaps, are the improvements in gear silence and ease in shifting, the latter being one of the inherent advantages of free-wheeling. Despite the increase in size and weight of many models and improved construction and appearance, prices are generally lower and values greater than ever before.

Although the trend toward cylinder multiplication continues, the new Marmon is the only car beside Cadillac having an engine of more than eight cylinders. At least two other makers, however, have developed twelves which may be ready for the market later in the year. Marmon's sixteen is a 45-deg. V-type engine with both cylinder blocks and upper crankcase cast from aluminum alloy in one piece and having inserted steel cylinder liners. This engine weighs less than 5 lb. per hp., and is said to develop 200 b.hp.

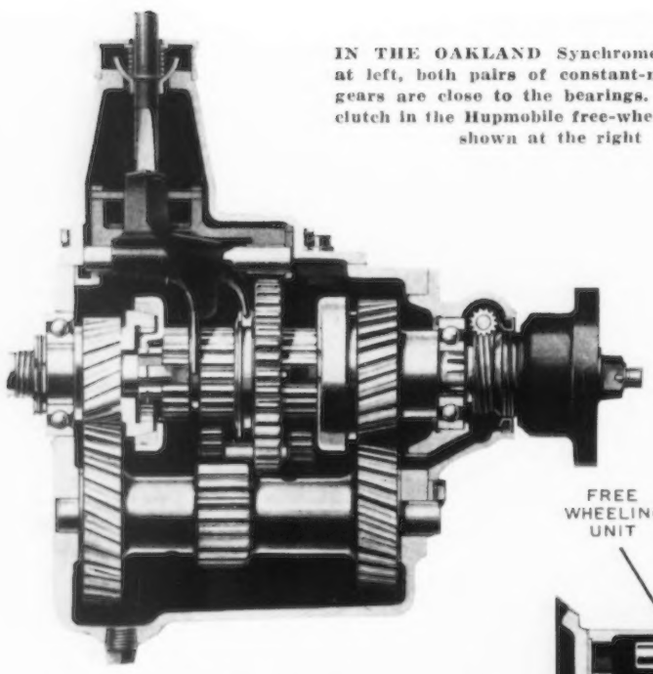
A large majority of new cars have eight-cylinder-in-line engines, but there are also some new sixes and one new four, the Mathis, a French design modified somewhat for American production by Durant engineers. This is a diminutive car, only slightly larger than the Austin, and intended to carry only two persons.

Four-speed gearsets have been dropped by some makers, chiefly because Amercian users are disinclined to do any more gear shifting than necessary, and unless they will do so there is no worth while advantage in four speeds. Large reductions in rear axle gears are required to give satisfactory performance, hence the average engine speed is not reduced, as it could be otherwise.

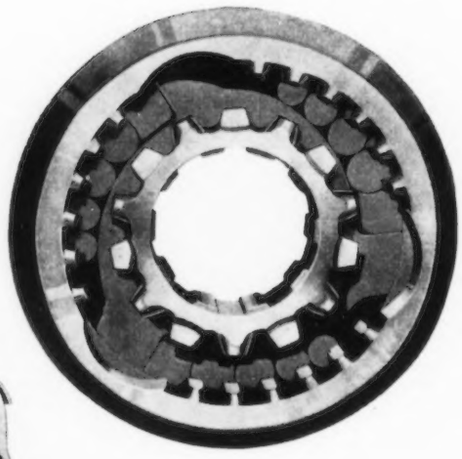
Most makers except Chrysler and Peerless have dropped the internal gear

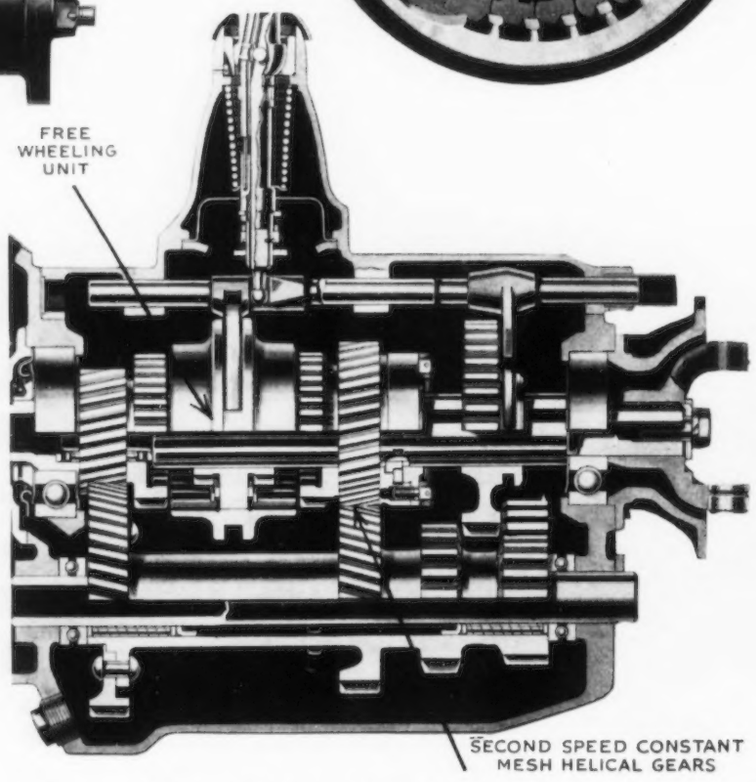


PARTLY because of its high power-weight ratio, this Marmon 16-cylinder engine was voted the outstanding automobile accomplishment of the year. It is mostly aluminum but has hardened steel cylinder liners



IN THE OAKLAND Synchromesh gearset, at left, both pairs of constant-mesh helical gears are close to the bearings. The roller clutch in the Hupmobile free-wheeling unit is shown at the right





LINCOLN'S new free-wheeling gearset, at right, is similar in general design to that used by Pierce-Arrow, Hupmobile, and Studebaker

and, in common with several makers who never used this type, have chosen helical spur gears instead to reduce noise in operation. Pierce-Arrow has abandoned the herringbone type in favor of the helical gear, leaving Reo as the only user of herringbones. Both these types are kept in constant mesh and shifting is effected by positive gear-tooth clutches which, because of their low inertia, facilitate shifting. In addition, at least seven makers now fit synchronizing devices in the form of small cone clutches which bring parts to be positively engaged to the same speed prior to engagement.

The patented Synchromesh transmission, first used only by Cadillac and La Salle, now has been handed down to all General Motors cars except Pontiac and Chevrolet. At the moment, the Oakland and Olds variations have silent helical constant-mesh and second-speed gears, but Cadillac, La Salle, and Buick have straight spur gears.

Two types of free-wheeling devices are being supplied. The first of these, now standard on all Studebaker, Pierce-Arrow, Hupmobile and Lincoln models, is virtually identical in general design on all these cars. It is controlled by the same lever used to shift gears. When a latch or top of this lever is pressed a slightly longer motion can be given it, thereby locking the over-running roller clutch and eliminating the free-wheeling effect, so that the engine can act as a brake. The arrangement of gears is such that the free-wheeling unit is inoperative in low and reverse.

Auburn, the fifth American maker to adopt free wheeling, has an entirely different arrangement. The free-wheeling unit employs an unwinding square-section helical spring inside a drum as the clutching member. It is in a separate compartment just back of the gearset, has a separate lever for throwing the unit into or out of engagement, can be used or not, as desired, in all forward speeds, but is locked out automatically when the gearset lever is shifted into reverse. This device, produced by the L.H.S. Company, a Cord Corporation subsidiary, is the same in principle of operation as a similar device used in Europe.

Some automobile engineers are not completely sold on the idea of free wheeling, partly because it involves more frequent use of and dependence upon brakes, but others feel that it may be adopted

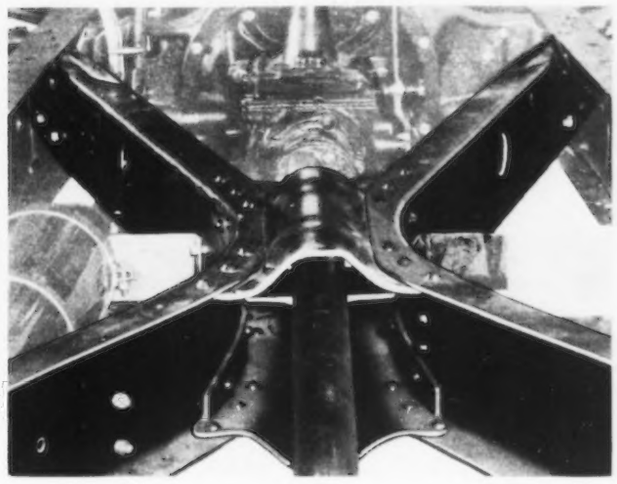
as generally as four-wheel brakes have been. Certainly the trend is in that direction and there appears to be no doubt but that brakes are adequate for the extra duty required of them. In any event, the effect produced by free wheeling is easily appreciated by the user, so that it has become an important sales asset.

Outside the gearset, changes in chassis design lie chiefly in detail refinement intended to promote quietness, make operation easier or afford a better body mounting. Frames on nearly a score of the new chasses have been redesigned to include kick-ups over both axles and a dropped section between, as this helps toward making bodies lower without decreasing headroom. Greater frame stiffness, resulting from lower-flange reinforcement in some cases and more rigid crossmembers in others, is a common objective intended to reduce body stresses, distortion, and consequent body noises. Axles have been lengthened to increase the tread to 61 in. in some cases, making possible wider and more comfortable rear seats.

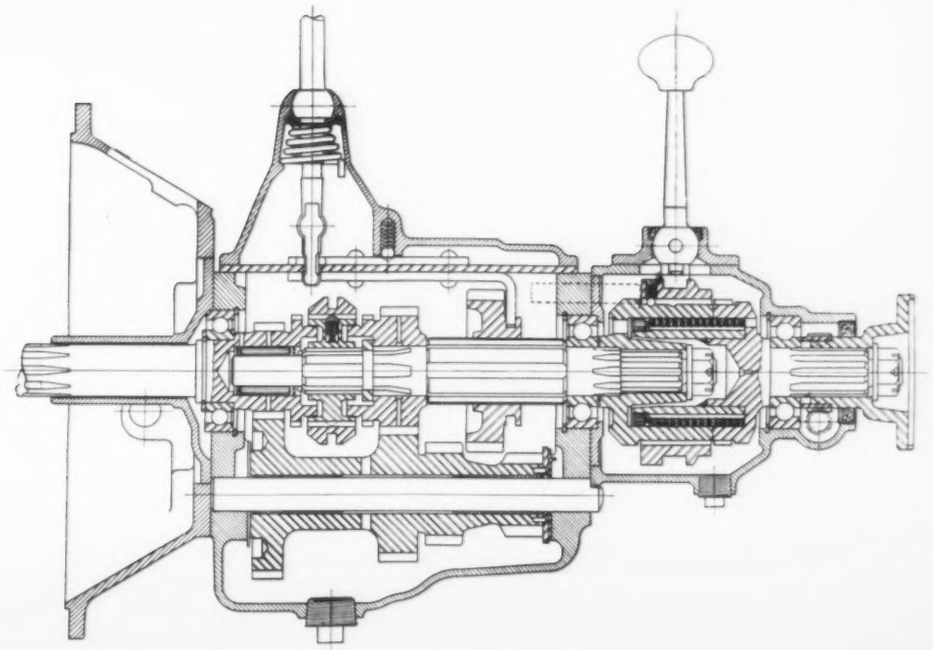
A further decrease of wheel diameter (to 17 in.) has helped to accentuate lowness, but unfortunately has decreased the road clearance which already was less than many engineers consider adequate, especially for cars used on soft rural roads. More cars are now furnished with wire wheels as standard equipment. Drop-base rims, which make it possible to change tires without tools, also are seeing wider use. At least one company is offering a spoked wheel stamped from stainless steel, and wooden as well as metal demountable wheels are more common.

A noteworthy innovation is the more extensive use of rubber, not alone to promote quietness and to absorb small vibrations but to substitute a flexing within this cushion for motion between metal-to metal surfaces. In addition to avoiding wear, the need for lubrication is obviated. Thus rubber bushings, inserted under pressure, so as to carry quite high unit loads, are substituted for metal bushings in such applications as spring shackles and shock absorber links, and sometimes are arranged with flanges to take end thrusts as well as radial and torsional loads. On one car rubber is used at forty points. It is applied in some instances in the hubs of clutch disks, vibration dampers and drive-shaft flanges, as well as in universal joints and in mountings for engines, gearsets, bodies, springs and the like.

Anti-friction bearings are being applied on the roller followers used in some of the newer steering gears to make steering easier, and double-shackled left front springs, fitted with supplementary cushioning devices to absorb road shocks,



STIFFER FRAMES help to minimize body racking. This X-bracing is used by Auburn



AUBURN'S free - wheeling unit involves an unwinding square-section helical spring and has a separate lever control

prevent shimmy and stop steering wheel "fight" are seeing wider use.

Engine refinements affect details primarily, and are directed mostly toward increasing power and smoothness or quietness of operation, bettering lubrication, or lengthening the life of parts. In line with these objectives are found combined air-cleaners and intake silencers; oil coolers and filters; vibration dampers, some of which have means for increasing their effectiveness by centrifugal means as speed increases; flexible mountings; valve spring dampers, improved designs of manifolds; and better balancing of parts.

Experience has shown that it is difficult to keep an oil film in plain bearings less than 1¼ in. in width, hence it is likely that fewer and longer main bearings will characterize future engines.

One manufacturer is electro-plating pistons with tin to make them wear to a fit more quickly. Some aluminum alloy pistons are now said to be good for 75,000 miles of use without excessive wear, whereas a 10,000-mile life was about the limit for ordinary alloy pistons a few years ago. Tests of valve springs have shown that good carbon steel lasts longer than alloy steel.

Finer appearance and improved lines characterize nearly all cars, as these factors are known to be of prime importance in influencing sales. In radiator lines many new designs show a marked leaning toward the style set by Cord a year ago, although no new models have adopted front wheel drive. Thus, the tendency is toward a radiator usually pointed with a divided panel narrowed toward the bottom. Fenders swept in sharply often accentuate the narrowness.

Certain Murray bodies, in particular, are said to afford much lower wind resistance, resulting partly from better stream-lining of the front, the sharply sloping windshield with rounded corners, and the elimination of an outside visor. The lines of Reo's Royal model are regarded as outstanding in this respect. Further study of wind resistance, perhaps even hastening adoption of chasis with engines at the rear, seems a likely development.

Body designers still strive for lowness in appearance, but fortunately seem to have concluded that actual decrease in head-room is not feasible. Lowness is accentuated, however, by deeper door panels and windows that are narrower in vertical measurement.

As a whole, the year shows an advance both in chassis and body design greater than that recorded ordinarily over like periods.

Lower Costs at Higher Prices

By Paul B. Swinton

"JUDGING by the papers on your desk, you're in the midst of profound calculations," I remarked, after I had seated myself in the chief engineer's office.

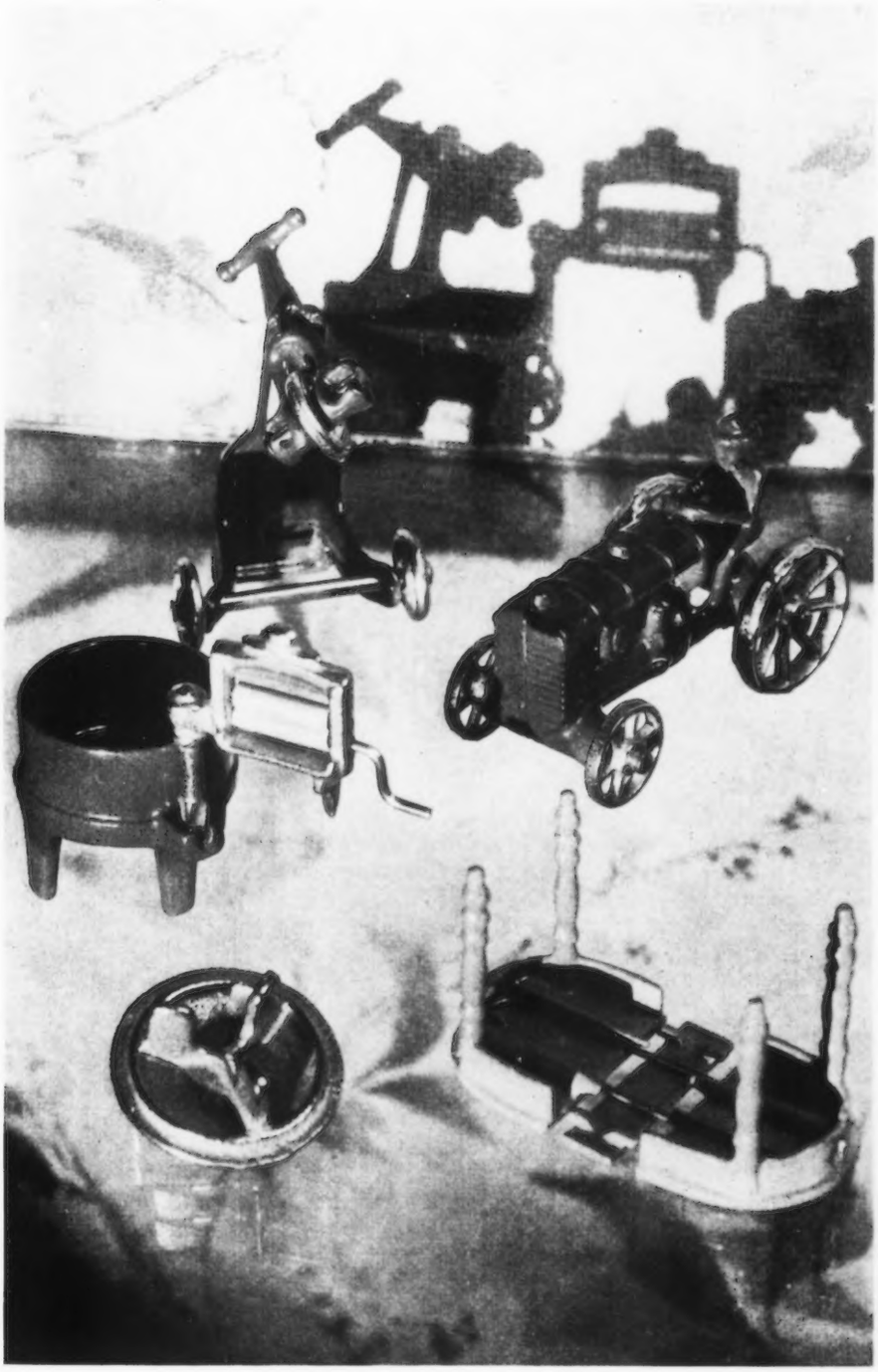
"Yes, and then some! We had quite a problem on our hands of figuring on using die-castings on our Model K household unit. Even after allowing for savings in machining costs and assembly operations, die-castings will add just $2, or 10 per cent, to the cost of the article. And this is not the time to try to sell at higher prices.

"But that is not the whole story. A few months ago our sales manager reported that he could increase sales about 40 per cent if we could cut our prices 10 per cent. That production increase would not help us much as we are down now, and furthermore, prices have already been cut to a no-profit point. What we need is a 100 per cent increase in production. That would give us cheaper material and lower production costs.

"This is my gamble: Better looking and more serviceable devices at present or lower prices will be demanded by the public when buying is resumed. My bet is that in addition to serviceability, style and appearance will be the predominating factors. In this case, die-castings will furnish those requirements. Assuming that the buying public associates eye appeal with quality, and I am sure it does, our re-created die-cast design, even selling at present prices, will look like an expensive article selling at a big discount. And that makes sales. With the resulting bigger production, our manufacturing costs will come down to a point, not 10 per cent, but 20 per cent less than the present estimated figure for the new design. In other words, the 10 per cent extra differential for die-castings will not only be eaten up, but an extra 10 will be saved to show a profit we don't have now."

"That sounds plausible, but what is your basis for assuming that a snappy appearance will boost sales as much as you think?" I asked.

"Well, experience has taught many people that, and history is bound to repeat itself. Crude appearing adding machines, clumsy washing machines, and ugly motor cars could be sold when nothing better looking was available, but when somebody started making a new model easier to look at, his sales jumped, and the fellow who didn't follow suit was out of luck. The artist's touch of beauty turned the trick."



DISTINCTIVE DESIGN FOR A DIME

By E. L. Peake

Chief Engineer,
The Kilgore Manufacturing Company

MEETING the price consideration in the design of small toys requires extreme care in design, backed by the minimum of machining and the best in finishes to gain the appearance and durability which means resale. Kilgore 10-cent toys are made principally of cast iron, and finished entirely by enamelling or nickel-plating. They are planned to form sets purchasable a unit at a time, so must be designed to give the value and durability which will make the purchaser "keep on coming back."

The "kiddy car" body, for example, is cast with axle supports and a slot for the steering post which require no machining. High-grade iron allows sufficient spring in the casting for the insertion of cast steering post. Parts are dipped mechanically in high-grade enamel which is baked on, before assembly. Axles are polished steel rod riveted over, the wheels are nickel-plated cast iron. Seven parts are assembled into this product which is retailed for ten cents.

A slightly more elaborate design is the washer and wringer, where the wringer and washer units sell for a dime apiece. The nickel-plated washer top casting incorporates realistic agitating blades which every child associates with a washer, and the enamelled body carries a socket for the wringer, a nickel-plated casting with true rubber-covered rolls that actually wring. The crank is riveted at its inner end.

Three parts of the table are cast iron, the fourth a U of high-carbon spring wire. Four lugs project below to hold the center leaf when it is inserted. The spring, sliding in grooves, provides the sliding feature.

Two-part construction is illustrated by the tractor body, cast in halves and assembled and held by a single rivet, lugs on one half fitting depressions in the other. More than 50 separate designs make up the line, which the designers aim constantly to increase and improve by "tricks" that give the customer quality and practicability for a set price.

DESIGN OR INVENTION?

By H. A. TOULMIN, JR.
Toulmin & Toulmin

"In design two and two make four— In invention two and two make five"

ONE of the most troublesome problems is to determine on which side of the line between engineering design and invention a particular product lies. Even the courts have never settled this question to everybody's satisfaction, save to establish certain guiding principles. Its importance is vital because a valuable patent asset may be lost through a misunderstanding of the situation.

Engineering departments that follow the rules established by the courts have a rather accurate guide to determine when they have an invention to protect and when they have only a design of mere engineering character on which no money should be spent in an endeavor to protect it. Skillful design is not necessarily invention, as an invention most often comes in a crude form. On the other hand, just because an idea has never been commercialized does not prove that it is a patentable invention.

Let us look at some practical illustrations of how this theory works out in specific cases. Practical cases decided by the courts are the only real guiding posts in this kind of analysis.

If any engineer had been asked a quarter of a century ago whether it would be invention to take a couple of pieces of fabric and bamboo, connect them by bamboo poles and twist the corners of the fabric by warping, something like an old-fashioned box kite, to make a supporting plane surface, that engineer would have promptly said no, and it would have been a good engineering answer. The two young bicycle repairmen who got up that contraption not only flew, but prevented their machine from turning over. Up to that time the problem of keeping a flying machine on a level keel had been unsolved. After that they combined a rudder and an elevating surface with these warping wings, which altogether made a satisfactory machine. But these plane warped surfaces were the heart of the matter. Now all of these elements—plane surfaces, the rudder, and the elevators—were old in themselves, as old as the box kite, but no one had ever put them into that new combination with that new result.

Hence, a new alignment of old parts securing a new or improved result is invention. The Wright brothers had met that test. The courts said that they had made a basic invention no matter how simple or how crude the original construction.

Then along came Curtiss who, instead of warping the wings as the Wrights had done, proposed to adopt the common swinging door idea and to hinge his door on the edge of the plane. That was a very practical step; it again was a new combination of old parts which got an improved result. Curtiss had thus provided ailerons that are used to this day. His ailerons are merely doors hinged on the side to the plane surface of the plane.

Right here let me point out that there are very few basic patents. The total issued in the United States is little over a hundred. Strange to say, more money has been made out of the practical improvements on basic patents than upon the basic patents themselves. Apparently the basic patent is so far in advance of the commercial development that its owner gets very little out of the income from the industry he has established unless he is fortunate enough to share in subsequent commercial developments surrounding improvement inventions.

HERE is another phase of the problem — When is a structure invention and when a mere aggregation of elements? A washing machine company made a clever contribution to the domestic washing machine business. Its development consisted in having a motor drive the dolly which stirred the clothes in the washing machine tub, and also drive the wringer together with certain apparatus for diverting the power from the dolly to the wringer and vice versa. A patent was issued saying that this was a patentable combination, and it certainly was a very useful commercial development.

In due season the patent was sued upon and the de-

fendant set up that this was not a patentable combination, but was what is known as an "aggregation." Now aggregation is the putting of two parts together so that the result is that two and two make four. This means that there is nothing new in the way of results from the assembly of parts other than the sum of the results of the parts. Invention is the putting of parts together with a new result, or, in other words, in invention two and two make five. Here then was a case where old results with old mechanisms were combined with no new function, despite the advantages of the arrangement. It was not a patentable combination, but an aggregation of elements.

IN A town in Ohio two inventors, troubled with the hard-riding cars of an early vintage, decided upon a new form of shock absorber. In those days the cross spring which extended across the Ford over the axle was supported at either end by a hook. These inventors removed the hook, placed a new hook in its place with a spiral spring supported on the end of the hook and then suspended the leaf spring on top of the spiral spring by a bolt that passed down through the center or on the outside of the coil spring.

Heretofore persons had tried shock-absorbing devices in which the leaf spring came first in the line of shock and then the coil spring, but not one had tried the light coil spring first and then the leaf spring which was heavier. This had formerly been assumed as impossible of arrangement.

Some $500 was the initial investment in the business for the manufacturing and selling of these shock absorbers. The Supreme Court of the United States found that this new arrangement of old parts was a marked invention. One court of appeals awarded a single recovery, against an infringer, of $292,000, and other courts have awarded large sums for the infringement of this invention.

Ordinarily, employing one known material in the place of another material is not invention, if the result be only greater cheapness and durability of the product. But, under some circumstances, substitution of materials will amount to invention. The dividing line is a difficult one to determine, but where the substitution produces a new combination and product having new uses and new properties, it is invention. However, in a case where door knobs had been made of iron, brass, wood or glass, the substitution of a clay knob was said not to be invention as the clay or porcelain had no function which the other door knobs of different material had not.

In the furniture business, Berkey found that the sockets for receiving the casters on which the furniture is supported were made in one piece. Many difficulties arose from the use of a one-piece socket. Accordingly, he designed a two-piece socket, the socket being provided with a spring made integral with one side of the socket so that the caster would be held in place and would not drop out when the furniture was moved or lifted. The caster was not so firmly held in the two-piece socket that it could not be pulled out when desired. Despite the obvious advantages of this arrangement, it was practically making in two parts what had been made in one part before. This, the court said, was not invention. The mere fact that the article was more durable in two pieces instead of in one, and that the cost of construction was cheapened, was not invention.

Can mere increased speed ever be invention, or is it only design? A recent case has established the guide posts that mark the boundaries between mere perfection of design and invention.

Fourdrinier paper making machines were known for many years prior to the advent of Eibel, but Eibel conceived the idea that the screen on which the wet paper stock is poured to form the paper and through which the water drains away from the paper to leave it in a dry sheet, could be elevated at one end so that the liquid stock discharged upon this screen would acquire, through gravity, an additional speed enabling the stock to keep pace with the screen at the critical paper forming point where the material passed from the liquid stock into a relatively dry paper sheet.

THIS arrangement avoided injurious disturbances of the stock when the screen was moved rapidly. By such an arrangement, it was possible to increase enormously the production of good paper on the same old machines.

In short, all that Eibel did was to take a horizontally traveling screen and elevate one end of it where the paper stock was dumped on the wire. It seemed that others had made a slight pitch of the screen for other purposes, but not for this purpose.

Ordinarily, the mere change of speed of a machine in order to increase its production is not invention. Increase of efficiency by improved design is customarily an engineering matter, and not a matter of invention. But here was a new conception bringing about a new result and a new combination from the old elements. The exact timing of the speed of the screen with the speed of the paper stock, which speed was acquired by the stock, actuated through gravity as it was poured upon the tilting screen was more than mere design; the Supreme Court found it was invention. The Court found this was invention in that Eibel struck the new combination of a wire pitch that would cause the pulp to travel faster due to the effect of gravity on the pulp.

Scarcely more than a hundred basic patents have ever been issued in the United States... Skillful design may not be invention... Invention is putting together parts with a new result

41 MPH

and sixteen horsepower

Speed, silence, and light weight, demanded in outboard motors, have been achieved by the use of light alloys and by able design

WHILE outboard motors are being produced in various sizes and in types from the single-cylinder to four-cylinder units, the most popular Johnson size is the model known as the B class motor developing 16 hp. This is a two-cylinder, two-cycle type of the two-port design, having a rotary valve which permits the gas to enter the crankcase gradually without any popping noise. It is produced in two models, one equipped with a single-unit motor generator, the other with a flywheel-type magneto. The bore of the motor is $2\frac{3}{8}$ in., and stroke $2\frac{1}{4}$ in., giving a piston displacement of 19.93 cu.in.

As in general automotive practice, the cylinders are cast of nickel iron, bored and honed to close limits, and the ports are milled to permit an equal gas charge to be delivered to each cylinder. Compression ratios used are 5.10 in commercial models and 7.05 in racing models. A reason for the selection of aluminum, in addition to its light weight, is because of its great heat conductivity to give better cooling. On account of the high speeds of operation, around 4,000 r.p.m., for the commercial models, Lynite pistons are used. They have two $\frac{1}{8}$-in. cast-iron rings placed 3/16 in. apart to permit the ring land to function as a cooling band at the higher speeds.

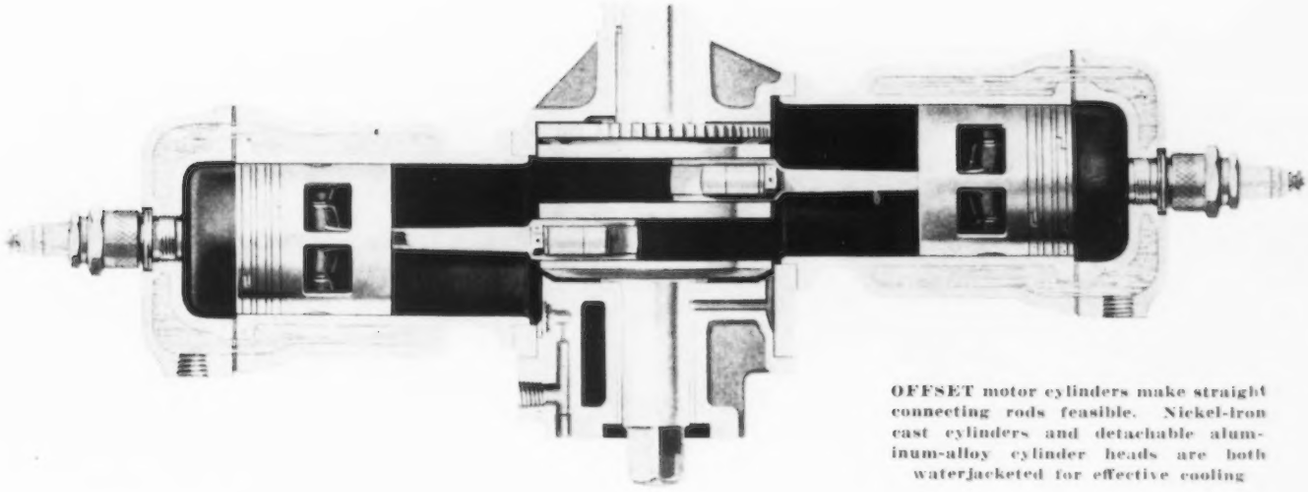
Motor connecting rods are drop-forged from low-carbon, nickel-molybdenum steel, and are mounted on the crankpins with roller bearings. On account of the integral crankshaft construction, a split retainer is necessary to hold the ten $\frac{1}{4}$-in. diameter rollers around the $\frac{7}{8}$-in. pin. For the outer race, the end of the connecting rod itself as well as the cap are used, both pieces being casehardened and ground smooth. These surfaces have a hardness between 54 and 57 Rockwell.

The cap of the connecting rod is held in place by two heat-treated nickel-steel capscrews. No tongue or dowel has been found necessary to hold the cap in alignment with the rod; the rollers of the bearing prove sufficient. At the piston end, hollow wrist pins are used, made from S.A.E. 2315 nickel steel hardened and ground. They are held in place by a lockscrew in one of the pin bosses. Pressed on the end of the rod is a hard bronze bushing, lubricated by splash.

In order to obtain high crankcase compression it was necessary to reduce the crankcase volume by having the crankshaft made with integral circular disk crank arms. The shaft is machined from a drop-forged, low-carbon, nickel-molybdenum steel with the crankpins and journals pack hardened and ground. These surfaces, as in the bearing end of the connecting rods, are also held to a hardness of 54 to 57 Rockwell. The main bearings are 1 in. in diameter, the upper being $2\frac{5}{8}$ in. long and the lower $2\frac{1}{4}$ in. long, while the crankpins are $\frac{7}{8}$ in. in diameter and $\frac{5}{8}$ in. in length. The lower end of the crankshaft is square for connection to the drive shaft on the lower unit, while the upper end is tapered to take the flywheel or armature core.

Because of the extreme light construction of the crankshaft, care is taken to see that no distortion occurs during the hardening process. Selection of the proper grade of steel and quenching procedure, however, play an important part in producing a shaft free from hardening strains.

The barrel-type crankcase is a semi-permanent mold casting of high-grade alluminum alloy, heat-treated. Its lower end is open for the purpose of assembling the crankshaft and has a removable casting holding the lower journal bushing. This casting is also faced for attaching to the drive shaft casing, held in place by four capscrews. Another piece bolted to the crankcase is the valve mechanism which controls the admission of gas into the crankcase. The valve is rotated on a vertical axis mounted on ball bearings and driven from the crankshaft through a gear keyed to the upper crankshaft disk. It opens the passage from the carburetor to the crankcase



OFFSET motor cylinders make straight connecting rods feasible. Nickel-iron cast cylinders and detachable aluminum-alloy cylinder heads are both waterjacketed for effective cooling

with an 89-LB. MOTOR

By WILLIAM R. BECKMAN

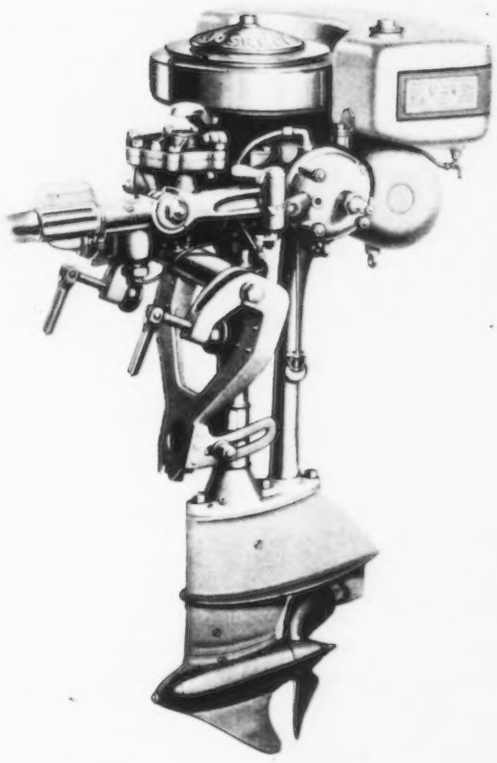
Director of Engineering, Johnson Motor Company

for 159 deg., and contributes to quiet engine operation by feeding the charge gradually and evenly.

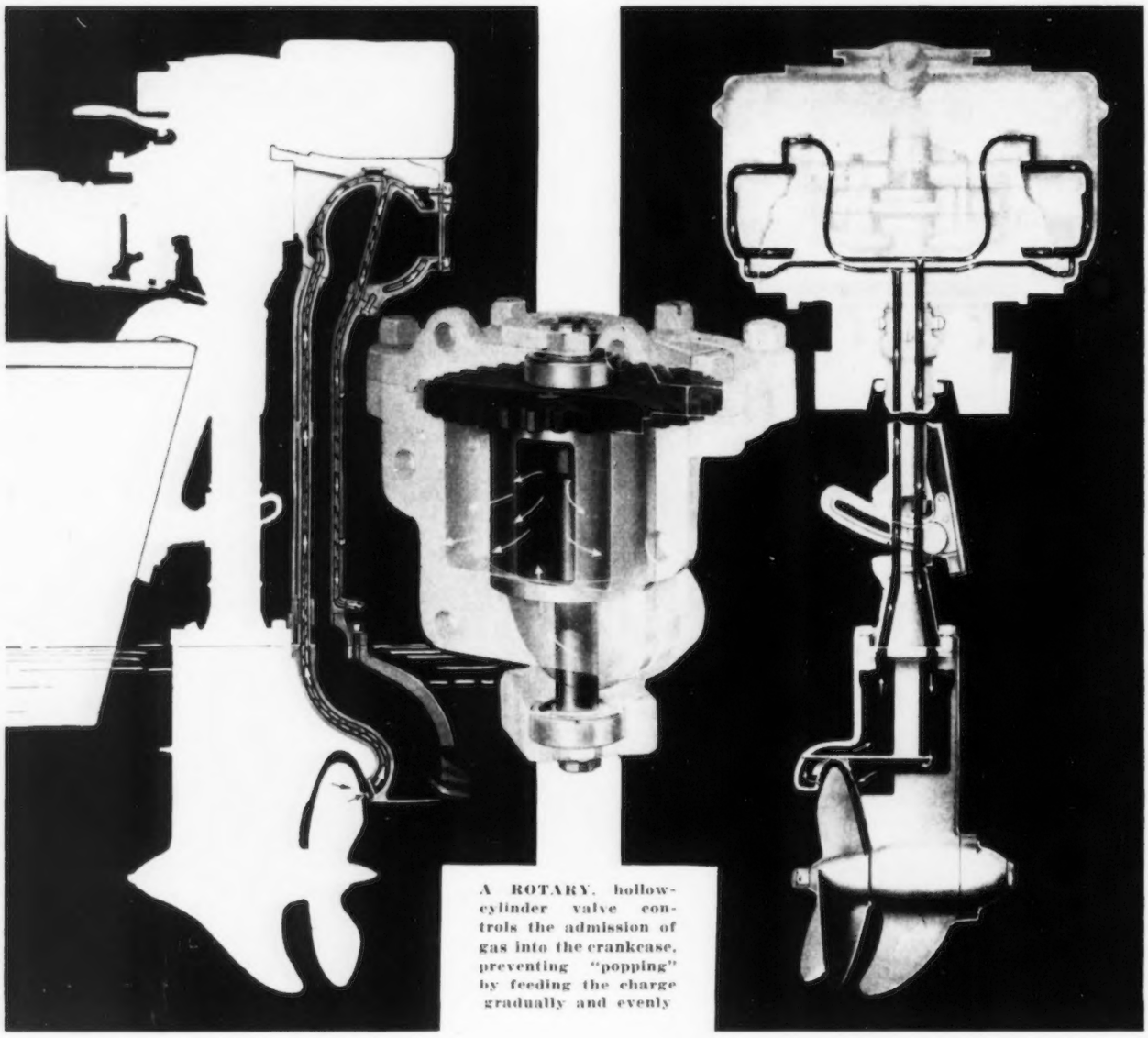
Carburetion is by means of a float-feed, plain-tube carburetor equipped with true Venturi fuel jets. Vacuum created in the crankcase causes air to pass through these jets at extremely high velocity. As this air draws the gasoline through a series of small holes drilled around the throat of the jets, the fuel is delivered into the crankcase in a finely divided mixture.

One outstanding improvement in outboard motor performance in recent years is ease of starting. This is accomplished by a release charger consisting of a cylinder valve located in the by-pass port of one of the cylinders. This valve is actuated by a small lever which is also used in opening a small poppet valve assembled to the cylinder head. By rotating the release charger lever, the lift valve in the cylinder head is permitted to open, thus releasing compression. At the same time the valve in the by-pass port closes the intake passage to the cylinder so that the entire gas charge in the crankcase, which is normally distributed to two cylinders, is forced into the active one on the opposite side. In effect, this amounts to supercharging the one cylinder. Furthermore, decreased resistance at the spark gap, caused by releasing compression, creates an increased intensity of the spark in the active cylinder. The released compression in one cylinder increases the ease of accelerating the flywheel and of pulling the motor over the compression in the active cylinder.

In the flywheel-magneto type of motor, a magnet is riveted to the inside rim of the flywheel and extends approximately 330 deg. around this circumference. This magnet forces the magnetic flux through a large coil, producing an intense spark at all speeds. A cam attached to the hub of the flywheel strikes the spark breaker blade which is the only moving part, opening the contact point and causing a hot spark. Control of the speed of the motor is by advancing and retarding the spark through a handlever extending from the armature plate. This lever is provided with a push-button which, at the will of the operator, short circuits the spark, stopping the motor. The coil and condensers are as nearly waterproof as it is possible to make them. By a combination of pressure and vacuum treatment, the coils are impregnated with wax.



STREAMLINED underwater parts reduce resistance and create an aiding suction at the exhaust outlet, placed underwater to eliminate staccato reports and obnoxious fumes



A ROTARY, hollow-cylinder valve controls the admission of gas into the crankcase, preventing "popping" by feeding the charge gradually and evenly

PROPELLER action provides water for the separate exhaust cooling system, which provides additional cooling of exhaust gases above the anti-cavitation plate

CYLINDER cooling water is circulated by utilizing propeller action to force water into the inlet and to create the vacuum that draws it from the outlet

For ease in disassembly, the drive shaft is divided into two parts connected by a splined sleeve coupling. At this point the gear housing is bolted to the drive column and may be dropped as an integral unit with the lower drive shaft member, which is supported at the coupling by a bronze sleeve bearing. At the lower end, a double-row radial ball bearing carries combined radial and thrust load from the bevel pinion. Similarly, a ball bearing on the propeller shaft carries the gear reaction as well as the propeller thrust. Leakage of grease from the gearcase, or of water into it, is prevented by a long sleeve bearing at the propeller end.

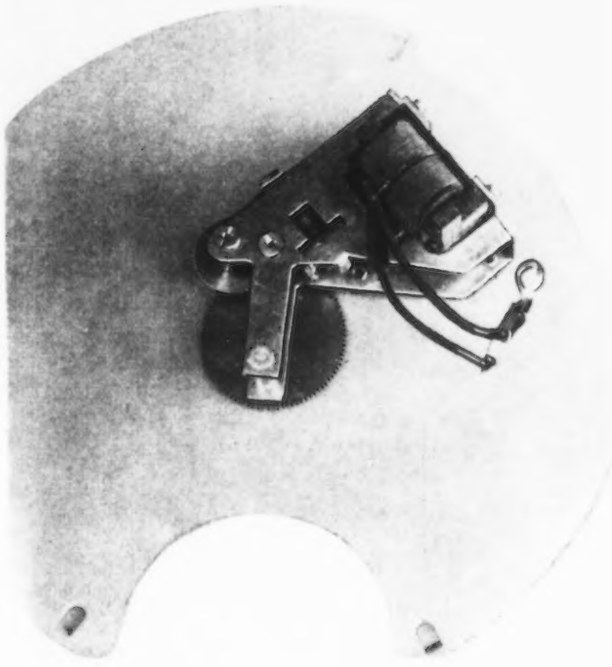
Adjustment of the mesh of the bevel gear and pinion is through the ball bearing on the propeller shaft. Its outer race has a sliding fit in the gear housing, and the thrust reaction is taken against a hollow cup, the position of which is adjustable from the outside through a threaded stud having a screw slot at its exposed end. To cut down water resistance, the cap that supports this stud is streamlined into the body of the gearcase.

The motor assembly is hinged into a stern bracket held to the transom of the boat by means of two lock screws. The thrust socket on the upper end of the stern bracket supports the weight of the motor, at the same time permitting it to swivel in order to steer the boat. Another socket is placed on the lower end of the stern bracket to take the thrust of the propeller. The longitudinal thrust socket is movable in a quadrant riveted to the stern bracket to allow setting of the motor assembly in a vertical position with respect to the water surface. Obviously, this position varies with the angle of transom in the boat. As a safety device, the motor is permitted to tilt even further back should any object in the water strike the lower portion of the gearcase. The tilting device also permits replacement of the propeller shear pin without removing the motor from the boat.

✦ ✦ ✦

SUB-SYNCHRONOUS AND STANDARD-SPEED MOTORS

COMPARATIVE size of these 200 r.p.m. and 600 r.p.m., 110 volt, 60 cycle sub-synchronous motors is shown by the fountain pen; the 200-r.p.m. motor is to the left



SUB-SYNCHRONOUS 600-r.p.m. motor mounted on the back of the dial plate of a rotating disk recording meter and operating in a vertical position. In operation, the armature is lifted by the magnetic field

Illustrations by courtesy of Westinghouse Electric & Manufacturing Company, Bodine Electric Company, and Janette Manufacturing Company

THE second of a series of articles on electric motor applications

AS A further important step in the development of motors for operating clocks and timing devices, sub-synchronous motors, which run synchronously at 200 r.p.m. or at 600 r.p.m. and are self-starting, have been introduced. These present many advantages over the synchronous motors which operate at 3,600 r.p.m., mainly because of the reduced speed.

The New Haven-Westinghouse electric clock uses a 200-r.p.m. motor of this type. This little motor, about 1½ in. in diameter and 1 in. high, is wound for 110 volts, 60 cycles. It draws 0.04 amperes and the watts consumed, only 2½, are inappreciable. The slow speed of operation does away with complicated gear trains, practically eliminates all noise, and gives the motor correspondingly longer life.

The 600-r.p.m. sub-synchronous motor, applied to metering devices, is even smaller than the 200-r.p.m. motor. It is usually wound for 110 volts at 60 cycles, and takes about one watt and 0.02 amperes. Application of this motor to a rotating-disk recording meter is clearly shown in the picture at the left. The motor is seen attached to the back of the dial plate and geared to the revolving dial in front. The motor turns the dial at a constant speed, allowing the pen, operated by the measuring instrument, to record its position on the sheet graduated in time. Thus, the sheet is a graphical representation showing the magnitude of the meter reading at any particular time.

In demand meters of the type illustrated the 600-r.p.m. motor is used to operate the time de-

vices and to reset the pointers to zero every fifteen minutes. Kilowatt hours are recorded on the counter in accordance with the revolving meter disk and at the same time the white pointer moves over the scale proportional to the kilowatt hours consumed during the interval, and therefore indicates demand in kilowatts. The black pointer has a friction bearing so that it remains in whatever position it is pushed when the white hand drops back to zero. The duty of the small synchronous motor is to keep the white hand geared to the disk-shaft for fifteen minutes, then to release it, let it drop back to zero, and again engage with the gear on the disk-shaft.

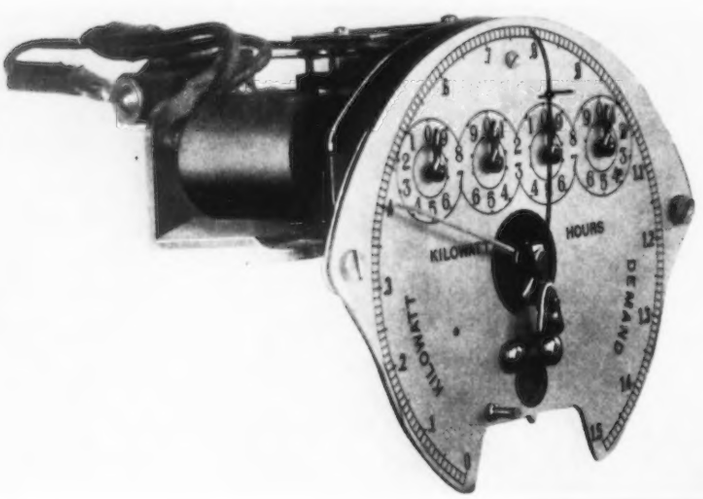
This 600-r.p.m. motor does not have sufficient power to drive a long roll of paper and rewind it on a collecting cylinder after the record is made. However, an interesting application of the motor is its use as an escapement for a spring clock powerful enough to drive a paper chart recorder. The usual balance wheel escapement is replaced by a synchronous escapement geared to the armature of the motor, giving rise to an arrangement with time-keeping qualities superior to the ordinary clock.

The escapement can be so designed that in case the electric power fails, the spring clock will drive the chart with fair accuracy, the spring then driving the armature of the motor against friction at a speed which gives an approximation of correct time.

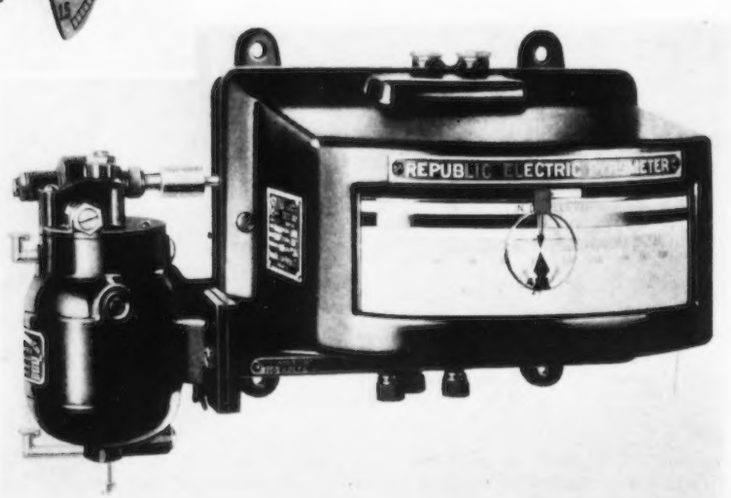
Nothing has been mentioned thus far in these articles pertaining to electrical classifications such as load, torque, duty, and other characteristics to be specified for the motor to be applied to a device. Though the product engineer who specifies the motor should have a general knowledge of the factors that must be considered in applying a motor to his product, the best results can be obtained only when he follows the recommendations of a responsible and trustworthy motor manufacturer. An almost endless variety of motors has been developed, each with its own special characteristics to meet certain factors involved in a given application. This phase of the subject can be treated only in a very general way in this presentation, but it will be shown that, unless the product engineer is a specialist in motor design, he should follow the recommendations of the manufacturer.

The first step in the selection of a motor for driving a given machine is to state what is wanted of the machine. With this established, the motor manufacturer is then in a position to design a motor to meet the conditions specified. Of course this is not always possible as the engineer may have set up requirements which cannot possibly be met. But a definite goal is set up, and rarely is it necessary to modify the specified requirements.

Speed at which the machine is to operate is one of the most fundamental factors to be considered. The driven machine may require a con-



CONTROLLED by a 600-r.p.m. subsynchronous motor, the white hand of the demand meter is kept geared to the meter disk-shaft for 15 min., then released to drop back to zero, and then reengage with the gear on the disk-shaft



WORM GEAR speed reducer designed to form an integral part of the motor operating an electric pyrometer

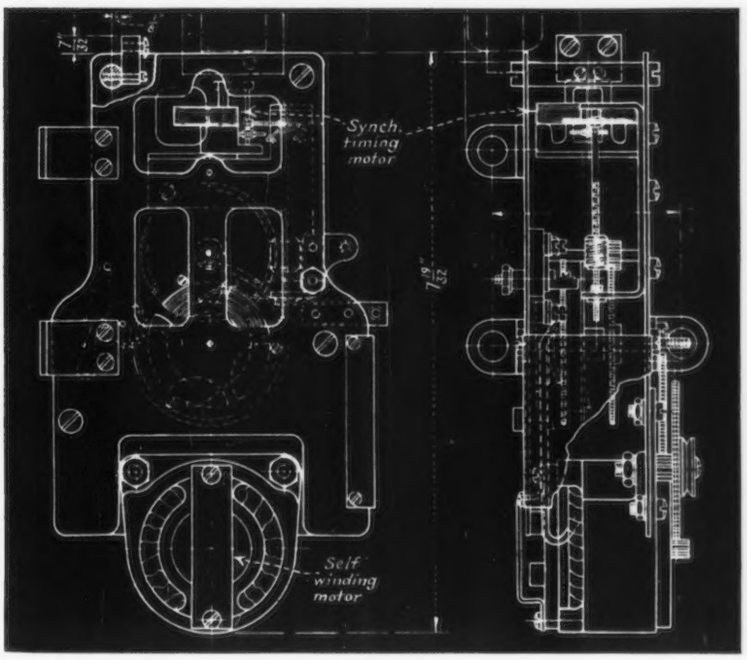
stant speed, variable speed, or multi-speeds, that is, several constant speeds. Motor manufacturers classify high speed as 3,600 r.p.m. or higher; intermediate speed as 1,200 to 2,400 r.p.m.; low speeds 500 to 1,200 r.p.m.; and very low speeds, below 500 r.p.m. Of course, frequently, gearing may be interposed between the motor and the driven machine in order to be able to use a motor operating at the most suitable speed.

In direct-current fractional-horsepower motors, (motors built on a frame smaller than that having a continuous rating of 1 hp., open type, at 1,700-1,750 r.p.m.) the rating standards adopted by the National Electrical Manufacturers' Association (Nema) are as follows:

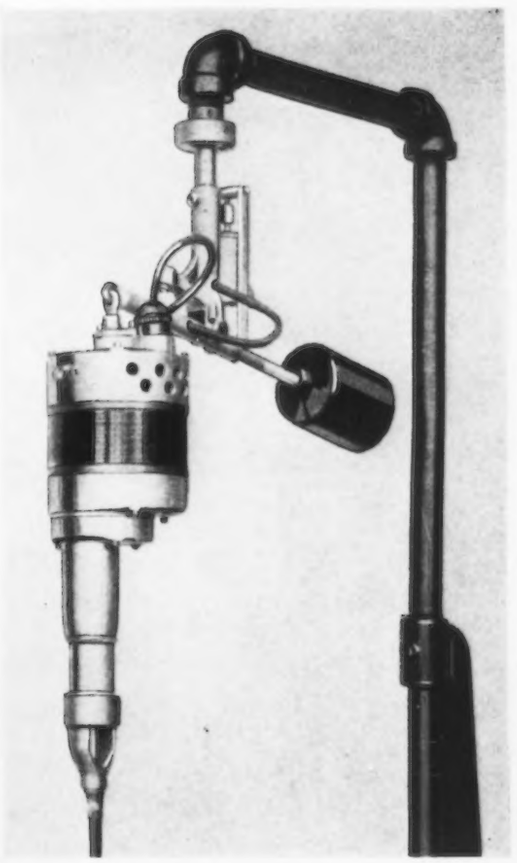
Standard full-load speed rating for d.c. motors from 1/20 to 3/4 hp. is 1725, with an additional standard speed of 1140 r.p.m. at full load for 1/3, 1/4, 1/6 an 1/8-hp. motors. The standard speed regulation of direct-current, constant-speed, continuous-duty motors from full-load to no-load hot, shall not exceed the values based on full-load speed shown in the table.

Horsepower	Speed r.p.m.	Per cent regulation Shunt wound	Compound wound
1/20 to 1/3 incl.	1,725	20	30
	1,140	25	35
1/3 to 1/2 incl.	1,725	15	25
	1,140	20	30
1/2 to 3/4 incl.	1,725	12	22
1/2	1,140	15	25

Variation in speed from full-load cold to full-load hot during a run of specified duration shall not exceed 10 per cent, based on the full-load speed hot.



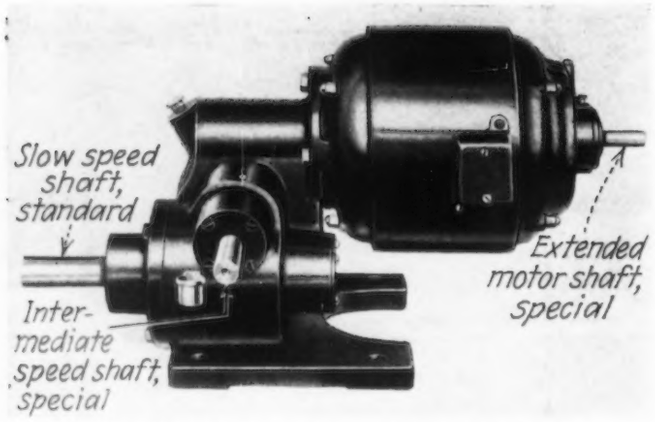
BALANCE WHEEL escapement is replaced in this design by an escapement driven by a sub-synchronous motor



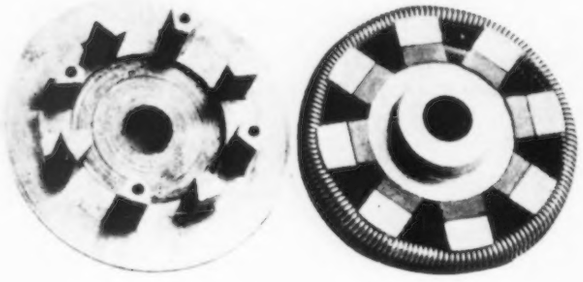
COMPACT hand tools that must operate at slow speeds can be designed by using a motor with built-in spur gear speed reducer, as illustrated by this motor-driven screwdriver

The above figures represent standards adopted by the N.E.M.A. Special d.c. motors for other speeds can be furnished, but there are limits within which the motor designer must work. Originally, direct-current motors were designed for such odd speeds as 1,300, 1,400, 1,600, 1,900, or any other speed that would suit the purchaser. However, as much apparatus must be designed so that it may be driven by either a.c. or d.c. current, the choice of motor speed may be limited because the speed of an a.c. motor is fixed by the number of its poles. Thus, for 60-cycle motors, the approximate speed of a 2-pole motor is fixed at 3,600 r.p.m., a 4-pole at 1,800 r.p.m., a 6-pole at 1,200 r.p.m. The speeds of the 4-pole and 6-pole 60-cycle a.c. motor have been selected as the two standard speeds for d.c. motors.

Usual requirements favor motors operating at approximately 1,800 r.p.m. The lower cost of manufacture favors the motor operating at ap-



THREE DIFFERENT speeds may be taken off of this motor with built-in double worm gear reduction



BY MEANS of this clutch, the driven device will continue at the set constant speed though the motor speed exceed its normal

proximately this speed. Also the 1,725-r.p.m. 4-pole a.c. motor is slightly shorter than the 6-pole a.c. motor having a full-load speed of 1,140 r.p.m. Bearing in mind the necessity for interchangeability between a.c. and d.c. motors, and the fact that the higher speed motors are cheaper, the advantage of the 1,800-r.p.m. motor is apparent.

Motor speeds can readily be reduced by suitable gearing, and as shown by the accompanying illustrations, the gear reduction can be built-in with the motor. For large reductions, worm gears are used, while plain, spur, or herringbone gears are used for smaller reductions. As an example, one motor manufacturer applies spur-type gears for reductions up to 6-1, while for reduction up to 432 to 1, worm gears are used.

It must not be assumed, however, that the designer is free to select a standard speed motor without considering the inherent characteristics of the machine being driven. Machines that must be started and stopped frequently require motors different from those for continuous operation. If the motor must be reversed, as in planer drives, the problem is still further complicated. In all such cases the inertia of the moving elements plays a very important part, possibly requiring not only special motors but also special controls. This subject will be treated more fully in a future article.

Constant load speed is frequently a desired asset, if not a necessity, in a motor-driven device. But constant-load-speed motors are relatively more expensive than variable-speed motors, hence a compromise must often be made to the extent of sacrificing constancy of speed of the driven device, or a mechanical governor must be interposed in the drive. However, there has been put on the market recently an ingenious clutch which will drive the device at a constant speed even when the motor speed exceeds the desired normal.

This constant load-speed clutch, as shown in the illustration, is quite simple. The outer or driven member carries a set of little brake shoes that bear on the inner drum which is the driving member. Above normal speed, centrifugal force begins to overcome the garter spring and the shoes begin to slip on the drum. This clutch will maintain its constant-speed performance substantially accurate over a wide range of driving speeds, and as to permanency, can transmit 1 hp. at 2,400 r.p.m. with 600-r.p.m. slip, continuously for 700 hours. By its use, a predetermined, constant-driven speed is assured even with inexpensive varying-speed motors.

+ + +

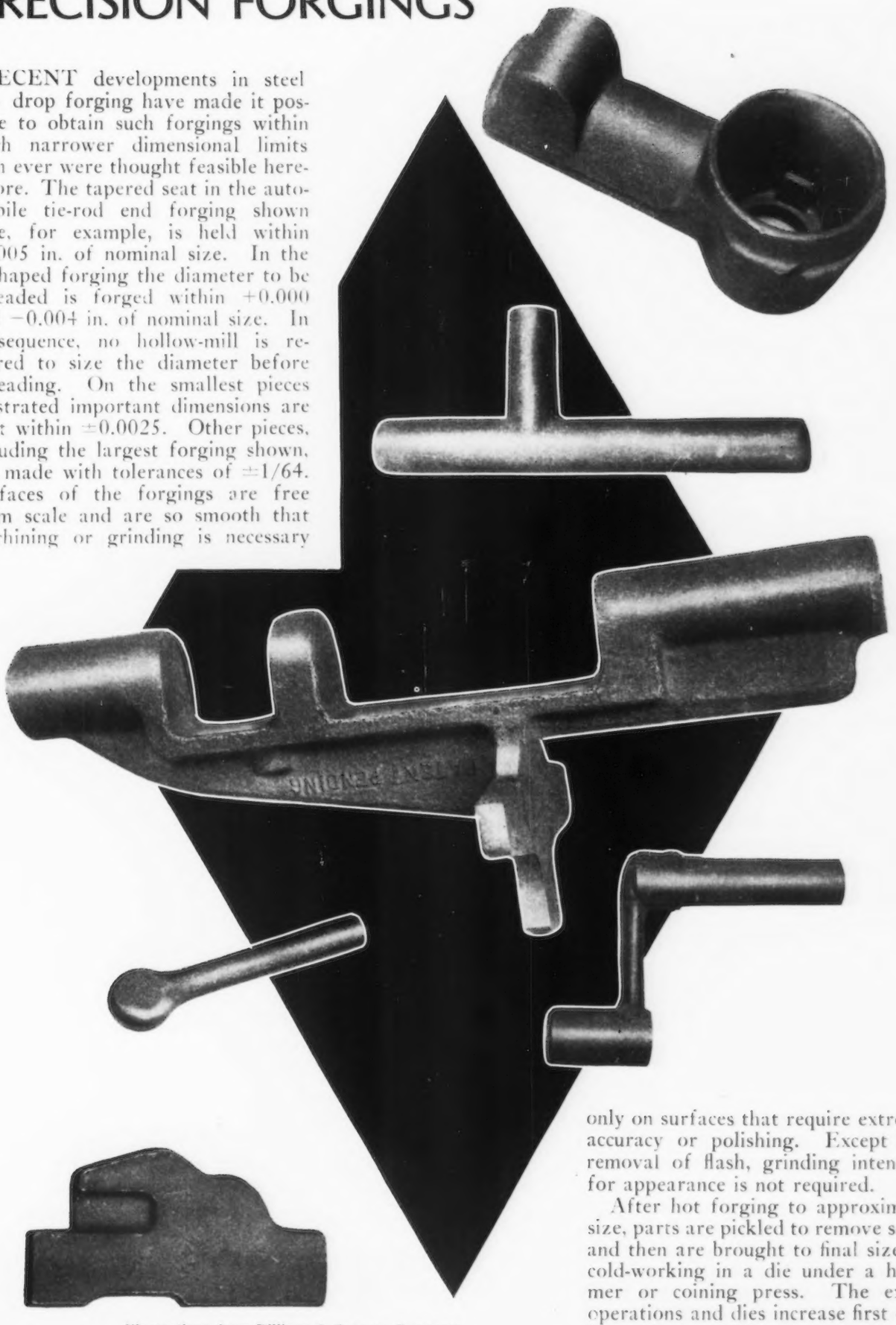
The Designer Meets the Customer

(Continued from page 51)

is to keep alive to improvements that are being made in materials, parts, and units that will affect his designs! In textile machines the need of expensive means of keeping oil from dripping onto fabrics was eliminated by improved oilless bearings and totally-inclosed anti-friction bearings. In radio, the designs were completely altered and simplified by the advances made by the tube manufacturers. The appearance and the requirements of many machines have lately been changed by new designs in motors, speed reducers, and control units. The designer may have put his utmost on his existing product, but an advance made by another manufacturer may make his design out-of-date almost overnight, or a new product brought out by someone else may altogether eliminate the market for his product. Examples can be enumerated where these things have happened in the past, but the probabilities that they will now happen are greater than ever before.

PRECISION FORGINGS

RECENT developments in steel drop forging have made it possible to obtain such forgings within much narrower dimensional limits than ever were thought feasible heretofore. The tapered seat in the automobile tie-rod end forging shown here, for example, is held within 0.0005 in. of nominal size. In the T-shaped forging the diameter to be threaded is forged within +0.000 and −0.004 in. of nominal size. In consequence, no hollow-mill is required to size the diameter before threading. On the smallest pieces illustrated important dimensions are kept within ±0.0025. Other pieces, including the largest forging shown, are made with tolerances of ±1/64. Surfaces of the forgings are free from scale and are so smooth that machining or grinding is necessary only on surfaces that require extreme accuracy or polishing. Except for removal of flash, grinding intended for appearance is not required.



Illustrations from Billings & Spencer Company

After hot forging to approximate size, parts are pickled to remove scale and then are brought to final size by cold-working in a die under a hammer or coining press. The extra operations and dies increase first cost but make machining unnecessary.

Molded Parts

DOOR HANDLES veneered with Lumarith present a permanently pleasing appearance, as do also the molded escutcheons and cases

MOST DESIGNERS are familiar with the strength and other desirable physical properties, as well as the unusual color effects which may be secured in pyroxylin plastics. However, the inflammability of pyroxylin plastic materials has been a deterrent which prevented its use in a large number of industries.

For more than twenty years chemists and engineers of the Celluloid Corporation have striven to develop a new molding material which would have all of the advantages of pyroxylin and at the same time be substantially non-inflammable. In 1927 this goal was achieved and a cellulose acetate molding material was produced on a small scale. The designing and perfection of equipment for volume production was completed late in 1929, and the new material under the name "Lumarith" was introduced.

With declining sales during this period of depression the executives concerned with selling a product turned to their product engineers for ways and means of improving the appearance of their articles in order to build up sales volume. Sales appeal is greatly enhanced by an appearance that compels admiration, but permanent sales value can be obtained only when beauty goes hand in hand with strength and permanence. Therefore, a molding material to meet the requirements of this modern age must possess an unlimited color range, stability of color, strength and resiliency. Furthermore, the molding material must be such that it can be used on present molding equipment, that volume production can be easily attained, and that the cost of the finished molded article be reasonable.

Practically any color effect, mottled or solid, can be produced in any desired degree of transparency, translucency or opacity. Color effects are greatly heightened by the luster. This natural surface finish is possessed by the article when it comes out of the mold, requiring no polishing operations. If desired, a highly reflecting surface and glass-like appearance can be obtained by etching and buffing. With the limitless combinations available, a considerable variety of beautiful colors and color effects is possible.

Average Physical and Chemical Properties of Cellulose Acetate Molding Material

	FILM	PLASTIC	PRESS POWDERS
Molding Range—Deg. F.	.....	260—300	260—300
Lb./in.²	.....	2000—10000	2000—10000
Tendency to Unmold	.....	Low	Medium to high
Thickness—1/1000 in.	1½—10	5 up	20 up
Machining Qualities	.....	Fair to good	Fair to good
Transparency— T = Transparent TL = Translucent O = Opaque	T	T, TL, O	TL, O
Colors and Mottles	Clear	Unlimited	Unlimited
Effect of Heat—Dry—Moist	More stable than nitrocellulose at 150 deg. C.		
Burning Rate	Low	Low to very low	Low to very low
Effects of Light —Sunlight	More stable than nitrocellulose	More stable than nitrocellulose	More stable than nitrocellulose
Ultra-Violet	Less than nitrocellulose	Less than nitrocellulose	Less than nitrocellulose
Effects of Aging	Slight swelling	Slight swelling	Slight swelling
Effects of Water—Cold	Swelled and attacked	Swelled and attacked	Swelled and attacked
—Hot	Slightly atacked	Slightly attacked	Slightly attacked
Effects of Acids —Weak	Decomposed	Decomposed	Decomposed
Strong	Slightly attacked	Slightly attacked	Slightly attacked
Effects of Alkalis— Weak	Decomposed	Decomposed	Decomposed
Strong	Spotted	Spotted	Spotted
Effect of Alcohols	None	None	None
Effect of Mineral Oils	.....	1.27—1.31	1.30—1.63
Specific Gravity	.....	21.8—21.2	17.0—21.3
Specific Volume—Cu.in. per lb.	10100	5400	1800—3200
Tensile Strength—lb. per sq.in.	35	13	0.2—0.5
Elongation—Per cent	.....	.....	0.17—0.62
Impact Strength—Izod	.....	.....	1.1—2.9
Modulus of Elasticity— Lb./in.²x10⁵	.....	45—65	.....
Hardness—2.5 mm. ball, 25 kg. load—Depth in 1/200 mm.	.....	.....	14—16
Thermal Expansion— 10-5/deg. C.	.....	5.4—6.3	5.3—8.7
Thermal Conductivity— 10-4 cal./sec. cm. deg. C.	.....	.....	0.31—0.37
Specific Heat—Cal./deg. C. gm.	.....	115—160	162—300
Softening Point—Deg. F.	.....	720	590—620
Breakdown Voltage, 60 Cycle volts/mil	1220	7.5	7.1—8.4
Dielectric Constant, 60 Cycle	5.3		

Properties of this cellulose acetate molding material may be summarized as follows: It is tasteless, odorless, substantially non-inflammable, non-shatterable, non-corrosive and does not deteriorate with age. In a transparent form it transmits ultra-violet rays to a marked degree. Physical and chemical properties are shown in the accompanying table. The material is light in weight and of homogeneous structure. It readily lends itself to machining operations such as sawing, drilling, routing and tapping, and finishing operations such as ashing, tumbling, polishing, etching, printing, stamping and engraving. If desired, pieces of Lumarith may be cemented together.

For molding purposes, the material is furnished in the form of powder, chips, or slabs from which blank forms can be cut for the molding operation. Powders, of a fineness to pass through a $\frac{1}{16}$-in. screen, are used princi-

# of Cellulose Acetate

BY J. F. WALSH

Vice-President, Industrial Research, Celluloid Corporation

Unlimited color range and effects, permanent luster, strength, and resilience are obtainable in products molded or veneered with this plastic material

pally in positive molds where the charges are carefully weighed and measured. Chips of different colors, of a size to pass through a ⅜-in. screen, are used for the production of beautiful variegated designs, and chips from mottled slabs produce still other exceptionally attractive effects. Unique decorative, stratified and mottled effects are obtained by using blank forms cut from slabs. Thus, almost any color effect that the product engineer may specify can be obtained without difficulty. Standard-size slabs are 20x50 in. by 5/32 in. in thickness.

For molding, the material is made in three types: hard, normal and soft, and all types can be supplied transparent, translucent, or plain or mottled opaque colors. The hard type is intended for articles having heavy sections where heat resistance and hardness are required, such as the housing for a motor contained in the handle of certain household electrical devices. Normal Lumarith, while not so hard, is appreciably tougher and can be molded into thin sections without the danger of cracking. It meets the average requirements for automobile hardware, clock cases, deluxe containers, and similar devices. The soft type is easiest to mold, very elastic, and adaptable to applications involving resiliency, such as golf ball covers. In addition to the three standard types of Lumarith, special variations of it are obtainable. Thus, an extra soft or flexible grade, resembling rubber or pliable leather, can be procured and used for coating artificial leather or fabric. This wide range of physical characteristics makes available a material that can meet the physical requirements in its field.

Molding operations consist in heating the material to a temperature between 267 deg. F. and 365 deg. F., at which temperature the material becomes plastic, and pressing it to the desired shape in the mold. The heating is done in the mold, though sometimes the material is preheated. There are no chemical reactions involved, and the overflow and scrap material may be reworked, eliminating all waste.

In addition to molded products, with or without metal inserts, sheets of the material may be used for veneering on wood, metal, or plain molded articles. This is made possible by the fact that special cements have been developed which enable the sheet to be firmly affixed to the surface it is covering. For some applications the sheet material is heated and stretched over or around the object it is to cover, and when cool it shrinks, thus forming a very tight and complete coverage of the article. Wooden clock cases may be treated similarly. In fact, almost any article may be veneered with this material.

Today, rods and tubes are obtainable in sizes from ⅛-in. to 2-in. diameter, varying from ½ in. to 60 in. in length. These are used in making model articles of complicated shape. They are also used for direct mechanical applications. Machining operations involve no difficulties.

Articles made of this cellulose acetate molding material, solid or veneered, may have their surface embossed, engraved, lettered, or decorated with metallic foils. These operations are performed in the same manner as with celluloid.

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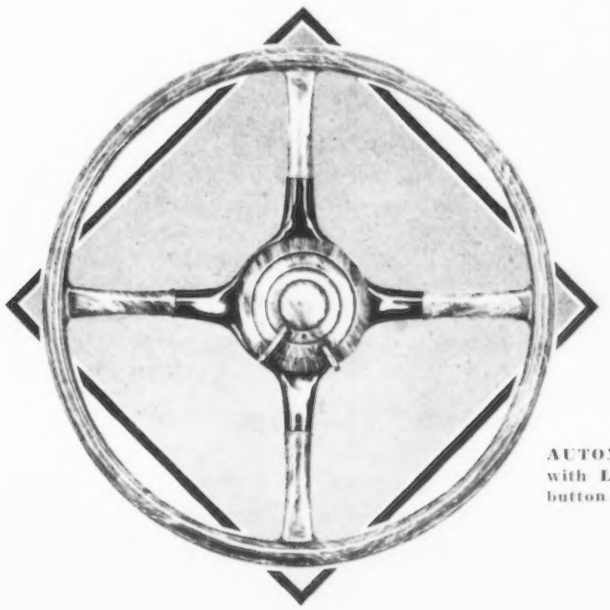
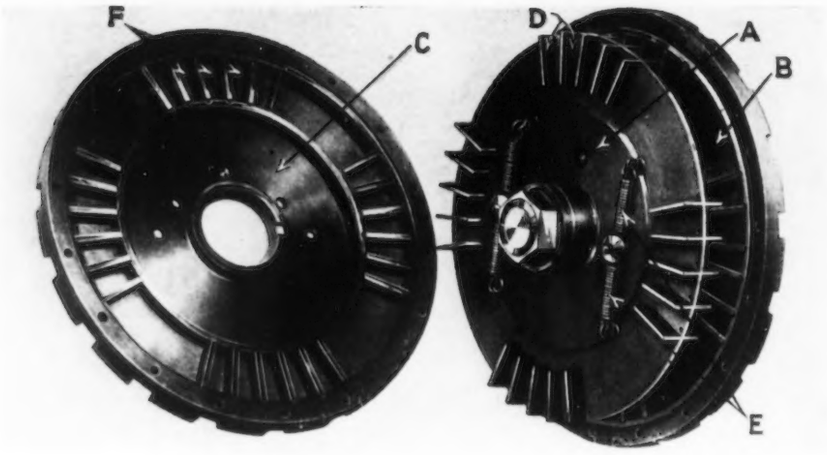


AUTOMOBILE steering wheel veneered with Lumarith. Control levers and horn button are molded of the same material

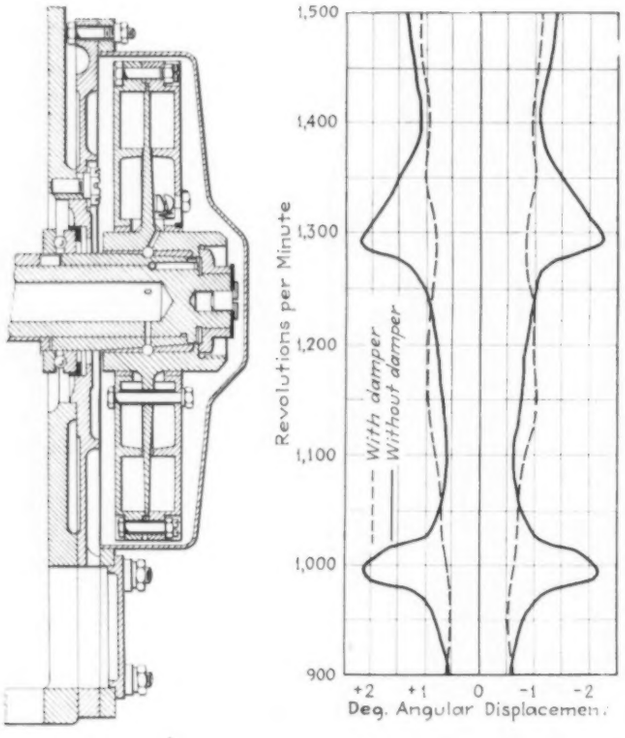


JUNKERS torsional vibration damper partly dismantled to show vanes and pockets in which oil produces the damping action

Vibrations Damped by Fluid Friction

By K. O. Wittmann

Engineer, Berlin, Germany



DAMPER and end of crankshaft. Right—Graph showing effect of damper in reducing torsional vibrations at various engine speeds

FLUID friction, rather than mechanical friction, is utilized to produce the damping effect tending to eliminate torsional vibration of the crankshafts of some Junkers aircraft engines. One reason advanced is that fluid friction is more readily controllable and cannot bring about seizing in any event. Engine lubricating oil is the fluid used.

In the Junkers design, here illustrated, the disk *A* is keyed to the crankshaft, and on its hub the damping disks *B* and *C* float. Springs *E*, which are relatively "soft," are hooked between the keyed and the floating members in such a way that, when the crankshaft is not rotating, the vanes *D* are positioned midway between the mating vanes *F*. Spaces between the respective sets of vanes are filled with oil. Any relative motion between the keyed disk and the floating disk, such as would result from torsional vibration of the crankshaft, tends to compress the oil on one side of a vane and to produce a partial vacuum on the other side, causing oil flow from one side to the other through a slot or clearance space. The fluid friction set up in this flow dissipates the energy released by, and damps out, the torsional vibration. Any heat generated is carried off in the oil, which, coming from the main bearing, circulates through the damper and is returned to the sump. Loss of oil is prevented by using a tight housing.

Although designed for use on models L-2, L-5 or BMW-4 Junkers engines, variations in the size of slots and number of damping chambers between vanes make the damper adaptable to a wide range of other engines. The damper has lately been generally introduced on German air service airplane engines.

What of UNDERCOATS?

Some factors that govern the type chosen . . . .

LEADING AUTHORITIES on finishing contribute many facts useful to engineers in this brief symposium

TO SECURE a satisfactory final finish on most products, the undercoats upon which it is applied must be given careful consideration, assuming that they are to be used at all. In some cases the nature of the undercoats is the controlling factor in determining the nature or quality of material from which the product itself is made. This is one reason why engineers are finding it increasingly important to know the why and wherefore of undercoats and to learn which type will best meet a given set of conditions.

Two general classes of undercoats, commonly called primers and surfacers, are employed. A most important function of a primer is to form a bond between the surface to be finished and the overlying coats. Good adhesive qualities therefore are a primary requisite. On surfaces subject to rust the primer serves also to put inhibitive pigments in contact with the metal and to form a film through which water cannot permeate. Surfacers, applied over the primer, serve to fill inequalities in the surface and when rubber or sanded, provide a smooth foundation for the finishing coats which follow. They vary greatly in consistency, from a free-flowing liquid up to a paste or putty, and are variously named.

Prior to the introduction of lacquers such as are in general use today, undercoats having an oxidizing-oil base were used for nearly all applications. This general type of undercoat still is employed extensively. Its cost per gallon is the lowest of the three types of undercoats in general use. It undergoes oxidation in drying, and for this reason each coat must be applied and dried separately. with enough time between coats to assure substantially complete oxidation, if satisfactory life is to result. In consequence, the time element becomes an important factor, even though oxidation be accelerated by artificial drying at elevated temperatures.

With the general introduction of lacquers, which dry by the evaporation of the solvent, not by oxidation, and with much greater rapidity than ordinary oxidizing oil-base products, stress naturally was laid upon the rapidity of finishing, and the demand for faster-drying undercoats became insistent. Difficulty also was encountered in using oxidizing oil undercoats for lacquers, because the powerful solvents used in the lacquers tend to dissolve and loosen such undercoats. But complete oxidation, effected either by baking or by allowing ample time for normal air-drying, renders the film sufficiently resistant to this "lifting" action to make such coats satisfactory for use under lacquers.

Efforts to develop pyroxylin-base primers and surfacers, for use in all-lacquer systems of finishing, have not been uniformly successful, chiefly because of the difficulty of obtaining good adhesion. Some really successful undercoats of this type were developed, however, and saw fairly extensive use. They possess the important advantage of permitting the primer and one or more surfacer coats to be applied successfully with at most a few minutes for solvent evaporation between coats. This type of undercoat suffers two handicaps, however: the cost, for material, is relatively high, and the sanding, which is necessary on most high-grade work, requires much labor, unless special mechanical equipment is available.

Efforts to overcome these handicaps and still

retain the advantage of being able to apply all of the undercoats within a short space of time, led to the recent development of the third type of undercoats. They contain synthetic resins of either the phenol or the glyptol group, a solvent, a pigment and some drying oil which has been nearly if not fully pre-oxidized. Such undercoats have excellent adhesive qualities. They can be applied with relatively short intervals between coats, and the cost per gallon, though greater than that of oxidizing oil-base undercoats, is much less than for lacquer-base coats. Labor required in sanding is about the same as for the lacquer-base type. Today synthetic resin primers and surfacers are used with much success under top coats of lacquer or under finishing coats of other types.

This form of undercoat, unlike the lacquer-base type, undergoes a chemical change, termed polymerization, during drying, but absorbs little if any oxygen from the air. Consequently, primer and surfacer coats can be applied successfully with little time between for drying, but when all undercoats have been applied they usually are baked for 1½ to 2 hours at 160 to 175 deg. F.

These, then, are the three most used types of undercoats available today. Good results can be had with any of them, and in some cases, without any undercoat. The factors mentioned are among the most important ones in controlling which type of undercoat is employed.

Baking enamel or japan often is applied without any undercoating, and the same is true of some other finishes, including some lacquers and air-drying enamels, but in such cases irregularities of the metal show through the finish and often are intensified by its luster. In consequence, it is necessary when such a finish is used, either to start with a smooth surface, or to be satisfied even though some metal imperfections show on the finished article.

It often devolves upon the engineer to determine whether it will prove more satisfactory and economical to use a relatively rough-surfaced material for the product and depend upon sandblasting, grinding, or polishing, or some combination of these to smooth the surface before finishing, or to use surfacers to fill inequalities; or whether a smooth-finish material should be used in the first place. On high-grade products, especially for those that must withstand weathering, it is desirable to employ a primer in any case, unless a material such as baking enamel, which in itself has unusually good adhesive and protective qualities, is employed. On low priced products, surfacer coats and primers may not be used.

Choice as to types of primer and surfacer, as well as to other finishing coats employed, naturally depends in part upon the class of equipment that is available for application and drying, as well as upon the production schedule to be employed. This, however, should not be either an excuse or a reason for leaving the finish specification to production men alone. The engineer ought to take just as much part in specifying finishing materials as in specifying structural materials, for they often have as important an effect upon the success of the product as they do many other materials used in it.

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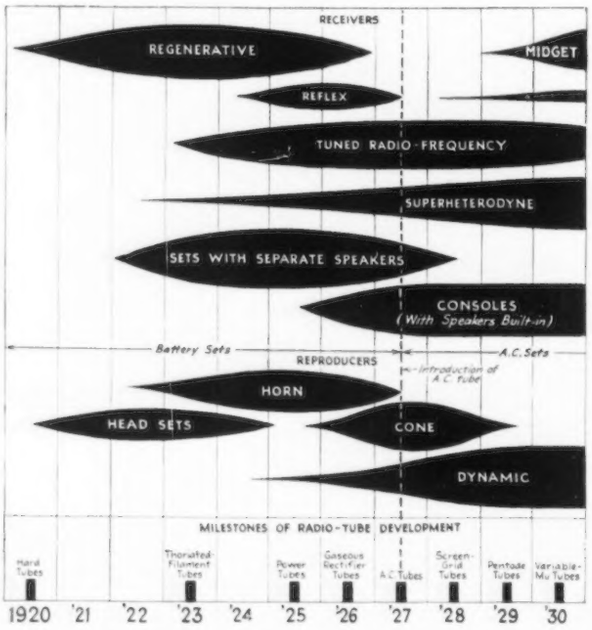
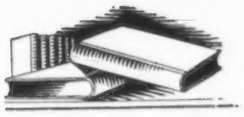


Chart from *Electronics*

LOOK TO PARTS DEVELOPMENT!

TAKING radio as an example, it can be seen from this chart that external developments can force redesign and changes in any line of products. Here the development of new types of tubes has affected the design of sets in use. Models and styles come and go, often influenced by progress made by specialized unit makers. What is true in radio is also true in machinery. New bearings, hydraulic control, automatic lubrication, new materials, and other developments affect the whole design.

Books for Engineers



ENGLISH-GERMAN-ITALIAN TECHNO-DICTIONARY. *By Hubert Hermanns. 432 pages, 4¼x6 in. Paper covers. Published by Hubert Hermanns, Berlin-Lichterfelde, Germany. Price $3.75.*

FOR ANY engineer who has occasion to employ the German and Italian languages, either for translation of technical papers or for correspondence, this dictionary will be found to be very convenient. It is divided into three parts so that the word in any of the three languages may be looked up directly. Explanations of the words are not included, the direct translation in one word being given in each case.

✦

ANNUAL OF AMERICAN DESIGN, 1931. *By the American Union of Decorative Artists and Craftsmen. Edited by Robert L. Leonard and C. Adolph Glassgold. 176 pages, 9x12 in. Cloth board covers. Indexed. Published by Ives Washburn, Inc. New York. Price $7.50.*

"IT IS a simple truism today that the maintenance of art-in-industry and of art-in-trade is an economic necessity," says Richard F. Bach in one of the ten short stretches of type that punctuate the 300 or more illustrations of designs in this book. Industry is the moving force that impels these designers. The fine, large halftones and the several prefaces all exude modernism, the clean-cut geometry of machine-work.

These designers employ metals and the molded plastics wherever practical in their designs. They discuss new materials, they invite the co-operation of manufacturers and offer their services in the effort to aid both sales and satisfaction by adding those fine touches of eye appeal to the product that make the prospective buyer burn with desire of possession. The book, by showing what they have done, might serve as a catalog of the wares of designers.

✦

NON-INTERPOLATING LOGARITHMS CO-LOGARITHMS AND ANTI-LOGARITHMS. *By Frederick W. Johnson, instructor in chemistry, California College of Pharmacy, University of California. About 120 pages, 6x8¼ in. Published by the Simplified Series Publishing Company, 1381 Third Ave., San Francisco, Calif. Price, limp cloth binding $1.60, Fabrikoid $2.25, full leather $4.*

ENGINEERS who use logarithms in making their arithmetical calculations are only too well acquainted with the time-consuming labor of interpolating. In this little volume the author presents non-interpolating tables arranged to give four and five place logarithms and anti-logarithms, and four place co-logarithms by inspection only, without interpolation. Each page of the tables is thumb indexed, which enables the user to turn immediately to the desired page.

In addition to those enumerated, the book contains tables for the reduction of small angles to seconds, formulas for S and T, and tables of atomic weights, metric conversion factors, chemical, physical, and mathematical constants, and other similar tables.

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AIRCRAFT PROPELLER DESIGN. *By Fred E. Weick, aeronautical engineer, Langley Memorial Aeronautical Laboratory. 294 pages 5½x9 in. Cloth board covers. Published by McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York, N. Y. Price $4.*

A COLLECTION of important experimental, practical, and theoretical information on the design and performance of aircraft propellers is presented in a simple, usable manner in this volume. Much of the material included is the result of the author's experience in experimental and design work, including that at the Bureau of Aeronautics, Navy Department, and on the staff of National Advisory Committee for Aeronautics in its Langley Field laboratory where he had charge of the 20-ft. propeller research tunnel.

An effort is made to bring out the dominating influence exerted by airplane and engine design upon propulsive efficiency. Chapters, such as that on gearing, viewed in this light, should interest aircraft and engine designers as much as the designer of the propeller. The book should prove useful also to engineers concerned with the design of propeller-type fans.

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ENGINEERING METALLURGY. SECOND EDITION. *By Bradley Stoughton and Allison Butts. 498 pages, 6x9 in. Cloth board covers. Indexed. Published by the McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York, N. Y. Price $4.*

INTENDED primarily as a general text for students in engineering colleges, this book should be useful also to engineers who feel the need of a general fundamental review of the structure of metals they are called upon to employ. The book covers an extraordinarily wide field, embracing ores and ore treatment, chemical metallurgy, metallography, metallurgical production, heat-treatment, and the application of metals and alloys.

The authors state that the book is for colleges where only a short course in metallurgy is given, but its greatest value should be found as a review text for advanced students who have already been grounded in the elementary studies, or for practical engineers who find it necessary to have a knowledge of the structure of metals. Engineers today, because of the increasing complexity of engineering materials, are compelled to give greater attention to fundamental metallurgy, and such a book, therefore, should be valuable.

COMMENT AND SUGGESTION

Finish Code for Drawings

By Edward Heller

IN one plant there is in use a code specifying the kind of finish that is required on the parts of the products manufactured. The coded finish marks are put on all drawings that go to the shop so that the men at the machines know exactly what is expected of them and how much time they need to finish various surfaces.

These five kinds of finish marks serve the purpose of the particular establishment well. They save questioning between the shop and the engineering department, and much time in the shop. The marks adopted are:

Ff—File finish. Usually put on surfaces for appearance or smoothness in handling, such as the finish on cast-iron handles or levers.

Mf—Machine finish. Finished by machining, such as planing, milling, or boring, for the sole purpose of bringing the surface to a dimension, or making it plane or cylindrical, as the case may be. Used on surfaces that have something fastened to them independently of anything else, such as the bottom pads on a machine bed.

Sf—Smooth finish. A finished surface for a member that has to line up with another part. A finish cut on a machine tool is nesessary.

Bf—Bearing finish.

Df—Drill finish. This mark is usually put on for holes where no reaming is necessary.

■

What's in a Name?

By J. A. Pouch

INVENTIONS and discoveries of the past generations usually bear the names of the men who made them. Carnot cycle, Diesel engine, Curtis turbine, Stephenson link, volt, ampere, joule, Bell telephone, and many other scientific and engineering terms are examples of this. The personal noun lends a touch of romance, and tends to bring to mind visions of toiling men who sweated for an idea.

Why should not modern designers, inventors, and scientists be equally honored by having their names attached to the fruits of their efforts? Theirs are the only permanent contributions to the progress of civilization; why should not their names be recorded in their works?

New York and New Jersey performed a very commendable act when they named the vehicular tube after chief-engineer Holland whose untimely death is largely attributed to strenuous efforts in accomplishing that great engineering feat. Other engineering accomplishments have been similarly named, but they are few in number.

It seems to me that the old custom of naming inventions, discoveries, and outstanding designs after the men who made them ought to be revived. Why not?

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STOP... LOOK... LISTEN...

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. . . WHAT FINISH? . . .

TWO companies making an identical product were found to be using different finishes—one an enamel, and the other lacquer. Neither seemed to know definitely just why, but there was a difference in cost and in results. There is a proper place for lacquer and a proper place for enamel. When will engineers fully appreciate that the right finishes are as important as the right materials in the product?

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. . . BACK TO CASTINGS . . .

STEEL stampings, or pressings as our British cousins call them, have been taking work away from the foundry for several years. Brake drums for motor vehicles were among the early victories for the steel product engineer. Now the foundryman is staging a comeback. Due both to the weak spots of the steel brake drum, among which are distortion and an inferior friction surface, users are willing to try anything that seems better. Newer and better alloys of cast-iron show several points of vantage over the pressed steel drum, at least in the minds of some users. So we find some well-known truck builders advertising cast brake drums as a talking point.

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. . . LEARN BY MISTAKES . . .

A FLYING MACHINE described in the "Mechanics Magazine" of June, 1830, was designed with four vanes revolved by hand power, and was calculated to lift 300 lb. But it didn't! Why? For centuries it has been taught that history is the most im-

Rear Engine Mounting

THE article by D. H. Montgomery on cars with rear engine mounting in the December number brought forth some interesting comments. The following is extracted from a letter from the chief engineer of one of the prominent automobile companies, the name of whom for obvious reasons is withheld. In his letter he makes the following observations:

In the early days of the automobile, engineers naturally considered many different arrangements, and some of the designs now proposed I think you will find were attempted and discarded in years past. Naturally, with our present knowledge of material and construction, some of these might perhaps be resurrected. I do not agree, however, with the paragraph in which the writer states, "The present car leaves almost everything to be desired."

I have found that no one design incorporates all desirable features. Designing at best is a compromise, accepting those features which are considered most desirable, but in every case involving, of necessity, some features which are not so desirable.

The front-wheel drive, which offers the body designer more pleasing ways of working out his ideas, certainly represents an advance in that direction. However, there is no question but that, in order to obtain this advantage it was necessary to accept a number of mechanical disadvantages, such as the consolidation of all units in front of the driver and the consequent increase of noise, which seems

to be almost insurmountable. In addition, there is an expensive service situation, and other mechanical troubles which have not thus far been satisfactorily overcome. In the last analysis, the car owner is not willing to sacrifice in favor of good looks.

Wherever the power plant is located, it takes up a certain number of cubic feet of space, and I question whether some of the buses with motors unconventionally placed have been entirely successful. The engine in front lends itself to the present artistic idea of long racy lines. In many cases hoods are made longer than is absolutely necessary, merely to satisfy the artist's viewpoint.

In order to popularize the rear engine job, such as the writer visualizes, it will be necessary to educate the public along other lines, so far as car appearance is concerned.

I do not want to convey the idea that I am opposed to changes in design, but I do believe they should be attacked a long way ahead from the artistic standpoint. Any radical changes cannot be attempted rapidly.

■

Who's Who?

By James A. Covington

IN THE last issue of "Who's Who in Engineering" are found names of some men whose contributions to the engineering profession do not warrant their inclusion, in the opinion of many engineers. But for this forthcoming book, a committee of the American Engineering Council "has laid down the highest standards ever used for inclusion in such a volume," these standards being used by the publishers. How will the records submitted and the standards set up be interpreted? The completed volume will answer this question.

It has been stated that many engineers eligible for listing have not yet sent in their biographies. It is probably a definite reluctance to be included in what they fear will be a motley list that is causing many engineers worthy of the name to hesitate in submitting their biographies to Who's Who. The forthcoming volume of that publication will determine what the attitude will be towards future compilations. In the meantime, those who consider themselves eligible should send in their biographies. Omission of names of men high up in the profession is more to be deprecated than the inclusion of a few whose engineering accomplishments possibly might not warrant it. portant study for the soldier, and the greatest military leaders have been intensive students of history. Isn't it also true for the product development engineer? Tracing the progress of product development over a period of years to study the errors and pitfalls of previous designers may sharpen the perception and make more apparent any foolish steps we are taking with our new products.

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. . . DESIGN OPPORTUNITY . . .

HARRISON CRAVER, director of the Engineering Societies Library, in New York, reports not infrequent requests for photographic copies, in English, of articles from French and German periodicals. This looks like a real opportunity for inventors who have exhausted the possibilities of ordinary mechanisms. It might even be attractive to a perpetual motion expert who is feeling a bit jaded. A translating camera would be a most interesting design problem.

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. . . ENGINES TO REARWARD . . .

SIR HERBERT AUSTIN, in a recent address, said many things regarding future automobile design that deserve emphasis. He anticipates the early development of automotive vehicles with the engine at the rear, and stressed the need for weight reduction, especially by building bodies as an integral part of vehicles rather than as separate units. Greater simplicity, through elimination of every superfluous part, he pointed out, also decreases chances for trouble. This applies, of course, to any machine, and should be kept in mind constantly by designers.

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STANDARDS . . .

WE recently saw several blueprints giving fits of various kinds and other details marked "standard," but these "standards" did not agree with any of the generally accepted standards and were misleading and indefinite. It is very important that both the authority for the standard and the date of its adoption be given when specifications or drawings are sent outside the plant.

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. . . OLD STUFF? . . .

A "SALES ENGINEER" complained that the mechanism of the newly developed design gotten out by the engineers of his company could be found illustrated in textbooks of the year 1880. Quite so, but that is nothing to complain about. Basically new mechanical movements are a rarity indeed. Even the much heralded "new free-wheeling" clutch now used on some automobiles has "whiskers" on it, as they say in the shop. Dr. Otto, inventor of the gas engine, also invented this same type of clutch and used it on his first engine. That was only about half a century ago.

Section Modulus, Not Moment of Inertia

IN the January number of *Product Engineering* there appears an article entitled "On the Square," by Paul B Swinton. The statement is made therein which reads in part ". . . the least moment of inertia in a square is that having a diagonal of the square for its axis. And the stiffness or resistance to bending is proportional to the moment of inertia."

May I point out that the second moment of area, or moment of inertia, has the same value for all axes in the plane of the square passing through the center, and is equal to $h^4/12$, where h is the length of one side of the square. There is no least moment of inertia, as stated, and therefore were the resistance to bending dependent solely on the moment of inertia the stiffness of the beam would be the same about any axis. However, stiffness is also inversely proportional to the distance of the extreme fiber from the neutral axis This distance is greatest when a diagonal is the axis, and the resistance of the beam to bending is then the least.

R. M. Nardone, *Project Engineer, Eclipse Aviation Corporation*

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Swinton is Wrong!

IN the article "On the Square" on page 6 of the January number of *Product Engineering*, occurs the statement "the least moment of a square is that having a diagonal of the square for its axis." This statement is incorrect. The moment of inertia as described above equals $\frac{a^4}{12}$ where a is the side of the square. The moment of inertia of the same section about an axis through its center parallel to one of its sides has the same value. However, the section modulus is less when the diagonal is taken as the axis. In this case it is $0.118\ a^3$. In the other case $0.167a^3$.

Furthermore, beams in being bent to a permanent set will yield about their "weakest" axis, which axis presents the least section modulus. Stiffness, which is related to the moment of inertia of the section, does not enter into the problem except when the elastic limit of the material is not exceeded. The author should have used "section modulus" instead of "moment of inertia."

David Fliegelman, *Chief Draftsman, Coppus Engineering Corporation.*

PRODUCT ENGINEERING

Editor: KENNETH H. CONDIT

February, 1931

. . . "Engineers . . . still find that electric fluid, imagination, absolutely essential to the achievement of results in the realm of the unexplored and unprecedented. Without it, science and engineering become dogmatic and sterile" . . .
—PROF. CHARLES A. BEARD.

The Way of the Progressor Is Hard

JUDGING from the general outcry against technological unemployment, the way of the progressor, the engineer who has made possible our amazing mechanical advances, is as hard as the way of the transgressor of the proverb. Professor Elliott D. Smith, of Yale University, who is responsible for the parody, maintains that the fault lies not in too much engineering of the product and of production, but in too little engineering of management and of merchandising.

The result of this unbalance of functions in a manufacturing enterprise is much like the result secured when two oarsmen of entirely unequal strength and prowess are given oars on opposite sides of a boat. Progress is in a circle instead of along a straight line, and there is more than an even chance that the strong oarsman will be berated for rowing too hard.

And so with the engineer. In design and production he has gone so far ahead of management and merchandising that the business craft is hardly progressing at all. The least suspicion of a storm nearly swamps it altogether. But do we hear complaints of the shortcomings of the other functions? Occasionally, but more often it is condemnation, in no uncertain terms, of those who are doing too good a job for the average of accomplishment. Truly, the way of the progressor is hard.

Try This on the Management

IT NOT only pays, but often inspires the designer, to wipe the slate clean occasionally, make valiant efforts to rid his mind of preconceived notions or prejudices, and then, reviewing his problem from a fresh angle, to design a brand new product from the ground up, striving to incorporate in it every reasonable improvement of which he has dreamed in flights of imagination.

Perhaps the design involved never will get beyond the layout stage, or perhaps it will prove much more feasible of realization than first appeared. But in any case it is likely to turn up possibilities that can be used at once or that will serve as marks at which future development can be aimed.

Unless something of this sort is done, the seemingly unavoidable restrictions upon design are more than likely to keep the designer in a rut from which he cannot escape. When the management imposes too close restrictions upon its designers it is almost certain to awake some fine morning to find that a more progressive competitor has stolen a march and is marketing a product decidedly superior to its own.

■

Less Noise!

THE Noise Abatement Commission of New York City has decided that construction and demolition equipment is noisy, very noisy, in fact, unnecessarily noisy. It has recommended an amendment to the city sanitary code restricting the use of such machinery "which, by its noise, shall disturb or annoy any person in the vicinity thereof."

Evidently the time has come for construction machinery designers to set about safeguarding the future of their products by ridding them of objectionable operating noises. And if this is true for the one type of machinery it will soon be no less true of other types. The sad part of the matter is that designing engineers have waited until they were driven to change by city ordinances. How much better if they had led!

Industry is fast awakening to the fact that noise takes a tremendous toll in health and effi-

ciency. The machinery of tomorrow will be silent, or practically so, and now is not too soon to begin making it that way. Better bearings, helical or other smoother running gears, composition gears, more carefully designed lever motions, designed-in motors—these are but a few of the steps the designer can take.

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Vision and Reciprocity

ONE of the best known builders of a standard machine recently visioned possibilities of a design that was radically different in many ways, that introduced new features and revolutionized past practice in many details. A customer, also with vision, wanted a better machine than any then built, and knowing the reputation of the builder, agreed to pay a good price for such a machine as he wanted.

One improvement suggested another until the new machine far surpassed the original conceptions of the best obtainable. But, fired with the desire for the best, the builder did not let the contract price limit the development even though the actual cost exceeded the price agreed upon by several thousand dollars. He considers this as an investment in progressive design that will pay dividends later.

Without such vision and courage industry would not have this machine available to add to its productivity. Industry must show its appreciation of such developments by displaying an equally broadminded policy in recognizing financially such engineering work. This way lies progress.

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Innate Modesty?

MOST editorials on the subject express strong disapproval of the failure of engineers to show the world their great accomplishments, to expand on the difficulties they had to overcome, and to shout the virtues of their brain child.

Is it modesty that deters the engineer from broadcasting promiscuously the mental process by which he arrives at his design? Would it enhance the engineer's standing were he to demonstrate principles he had discovered but that reflect on the design of the product of his company? Most engineers must submit their papers and speeches for company approval before publication or presentation, and broad minded engineers recognize the desirability, if not necessity, of this procedure. No engineer whose success is tied up with that of his company cares to trade his own future prospects and those of his company for passing applause. Even were he motivated by a keen desire for immediate financial gain, would his employer's competitors reward him for divulging facts that, for business reasons, should not have been broadcast? A betrayer reaps no reward.

Doctors and lawyers may well shout their theories from the house-tops. The latter especially, because they can always give vent to a tirade against their opponents. But when all is said and done, an engineer's job is purely commercial. He evolves material things which must be sold at a profit or be the means for manufacturing articles of trade more economically. His employer sees to it that his designs usually bear the trademark of the company and are known only as the product of that company. Good business sense dictates such a policy. Engineers recognize it.

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New Products for Old

HARD times have apparently struck some companies as "a blessing in disguise." There is the case of a New England manufacturer whose market for a certain product was slipping away from him, and it was not until the depression paralyzed the plant completely that he set his engineer to work to conquer the problem. The study and redesign unfolded an entirely new application and new market. New patents were obtainable to cover the new application, and the plant has already had to sub-contract to meet the 1931 demand.

There is another case of a manufacturer of an industrial scale who began to redesign for standardization of parts, and instead of merely decreasing his units as planned, he has developed certain phases into a new field where it became necessary to build a new plant to take care of a new line of profitable business. While some are still bemoaning the depression, others, by research and product engineering, are adding new lines and getting new business!

WHAT'S GOING ON—

The Month In Product Design

AIRCRAFT of all types continue to use metal more extensively in their construction. The Army now plans a metalclad dirigible modeled after the Navy ZMC-2, but four times as large—approximately the same size at the "Graf Zeppelin." It will be 550 ft. long, powered with 8 engines developing 5,000 hp., and will be able to cruise 3,600 miles at 70 m.p.h. It will use a multiple-fin control system to simplify maneuvering. Engines will be suspended in units of two. The ship will weigh 75 tons empty, and have a gross lift of 115 tons. The Handley-Page "Hannibal" biplane is also of all-metal construction. Its four motors are mounted two on the upper wing, two on the lower, while the fuselage is slung under the lower wing to gain ease in loading, uninterrupted view, and lessened noise. The top speed is 129.5 m.p.h., with a landing speed of 45 m.p.h. The over-all length is 86.5 ft., and passenger capacity is 38. Supercharged Bristol air-cooled radial motors are used.

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CLUTCH CONTROLS being manufactured by the Hill Engineering Corporation for motorbus use have a seamless steel cylinder fitted with an alloy piston on a cold-rolled shaft. By means of a valve operated either by hand or from the clutch lever, vacuum power is applied to the cylinder from the intake manifold. Thus vacuum power supplants the usual hand or foot power required to manipulate the clutch, reducing the required effort from 120 to 15 lb.

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SUN-LAMP units include one by the Bryant Park Electric Lamp Co., made throughout of cast and stamped aluminum with a Monel metal socket to preclude corrosion from excessive heat. The 16-in. reflector has an oxidized reflecting surface and the external finish is natural silver-aluminum. Another is an Esrobert ceiling type, which contains a V-shaped tungsten filament, two tungsten electrodes, and a pool of mercury enclosed in a bulb of special glass. Current passing through the filament heats it to incandescence, vaporizing some of the mercury, and an arc is formed between the electrodes. Finishes are antique bronze or antique ivory with a 16-in. oxidized aluminum reflector. A third, made for industrial use by the National Carbon Co., makes artificial sunlight available in units of high power giving radiation of natural intensity at a radius of several feet. It is the dual-trim carbon-arc type, utilizing only one pair of carbons at a time but shifting from one pair to the other as the carbon burns back. Feed mechanism is motor driven and operated by an automatic relay. Panels of special ultra-violet transmitting glass limit the radiation to rays common to natural sunlight.

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CLUB TOASTERS, made by the Ade-O-Matic Porcelain Products Company, are of cast aluminum, porcelain enameled in blue, green, or yellow. Raw mica and chromium-nickel wire are used in the heating elements.

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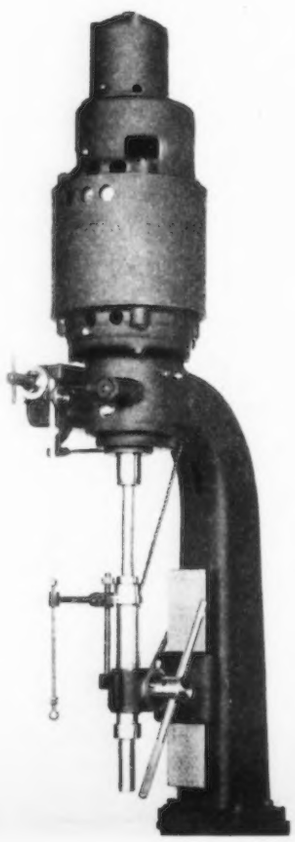
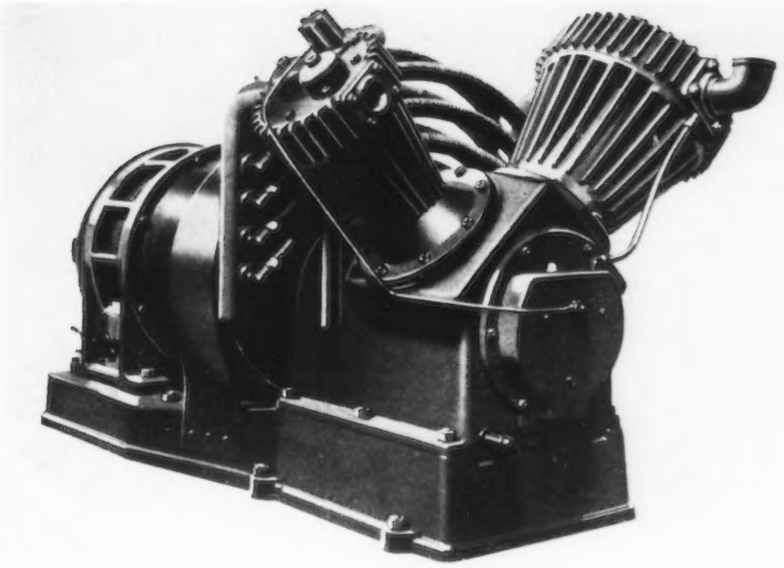
ELECTRIC WASHING MACHINES and ironers being brought out by the General Electric Company have an "Activator," claimed to start effective washing action at the water level and to give a downward tug which sweeps out air bubbles and pulls the clothes into the full-power washing zone. Machines are full-skirted and finished in two shades of harmonizing blue. Tubs are enameled porcelain, ripple finished. The mechanism is fully enclosed and protected. The machine is powered with a G.E. ¼-hp. motor, insulated with rubber, shock-proof, and cradle mounted with a transmis-

A Glance Over the Pages—

1. *Which have shown the greater profit and why, basic patents or patented practical improvements? p. 62.*
2. *What are the fundamental differences between the two types of free-wheeling devices now used on automobiles? p. 58*
3. *What compression ratios are used for outboard motors? p. 64.*
4. *What is one of the reasons advanced for using fluid friction in preference to mechanical friction for vibration damping? p. 74.*
5. *How is the amount of work required to reverse a rotating spindle calculated? p. 54.*
6. *Why were the speeds of fractional-horsepower, d.c. motors standardized? p. 69.*
7. *What are the trends in radio set design? p. 76.*
8. *Can the axis of a calculated moment of inertia be transferred graphically? p. 95.*
9. *Who will head the A.S.M.E. Research Committee? p. 86.*
10. *What undercoat is used for lacquer? p. 75.*



REVERSING motor applied to Leland-Gifford motor-spindle drilling machine to permit tapping. Reversal is accomplished by means of an automatic switch operated by the up and down movement of the spindle



INGERSOLL-RAND self-contained, direct-connected, two-stage, air-cooled compressor for train line charging service. Rated at 155 cu.ft. per min. piston displacement, the entire outfit is mounted on a single sub-base and weighs but 3,750 lb.

ing in contact with the product are of bronze also. Discharge rollers are of brass, with bronze ends and stainless steel shafts. Shafts operate in renewable phosphor-bronze bearings. Roller drive gears are of stainless steel, and the internal stationary gear at the discharge end is of U. S. Navy bronze. To prevent aeration, the machine is designed to avoid agitating the product. Tomatoes, fed into a slowly-revolving crusher through a hopper, are dropped after crushing on the screen, where two roughened rolls revolving about a shaft and about each other finish the squeezing process. The rolls are so designed that green sections of the fruit offer enough resistance to be slid or shoved along with the pomace or pulp, thus allowing no juice from green sections to be squeezed into the juice extracted from ripe portions of the fruit.

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sion sealed in oil. The ironer shoe is of rust-proof "Allegheny metal."

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CIRCUIT BREAKERS suitable for 15-amp. house branch electrical circuits have been developed by the Westinghouse Electric & Manufacturing Company to supplant the usual fuses. This circuit breaker is a combination of a quick make and quick break switch and over-current protective device. The switch is of the toggle type with the fixed center mounted on a swinging arm which is ordinarily latched under a catch on the bi-metallic thermal over-current unit. As long as the arm remains latched, the switch operates as any other toggle switch. But when the current through the bi-metal exceeds the limit, it releases the latch, the end of the toggle moves out of line, and the toggle promptly collapses and opens the switch.

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PORTABLE TRACK GRINDERS made by the Railway Track Work Company have now been designed for gasoline engines. The machine has double grinding heads operating independently on either rail, feed being regulated by a handwheel and worm above the grinding wheel. The 1,500-r.p.m. 4-cylinder engine develops 12 hp. at full speed. It has a double shaft extension, each shaft being connected to a main drive shaft which operates the wheel spindle through helical gears. All shafts run in double-row ball bearings. Grinding units and engine are mounted on a steel carriage which moves laterally on the machine frame.

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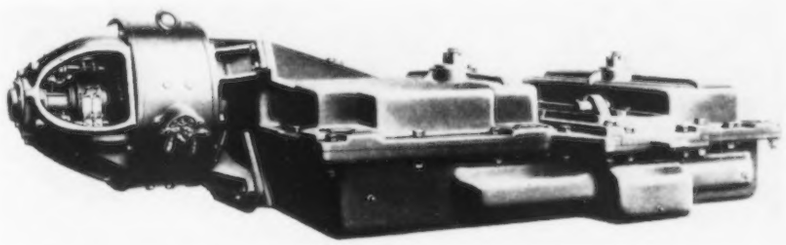
TOMATO JUICE EXTRACTORS made by the F. H. Langsenkamp Company have Monel metal screens, hoppers, hoods, underpans, and discharge chutes. The machine shaft is of Tobin bronze, and all castings com-

ALL-STEEL TUGS, 108 ft. long, 26 ft. beam, and 13 ft. draft, powered with Ingersoll-Rand Diesel engines, will be used in and around New York harbor by the Erie railroad. Each boat is equipped with two 500-hp. units, 1,000 hp. total. This type of tug is said to be most powerful in use in the port of New York.



COMPACT shaker conveyor drives of the Conveyor Sales Company attain correct relation between acceleration and retardation velocities by utilizing a gear train and cross-arm. Peak velocity of the forward stroke comes beyond 120 deg. of the full revolution and the peak of the reverse stroke before 240 deg., the ideal condition. All shafts are mounted in Timken bearings.

RING-SPINNING FRAMES, newly developed in England by the Textile Underclearers, utilize a spindle which has a blade similar to that of a mule spindle and is tilted toward the drafting rollers at an angle of 2 deg. from the vertical. There are no thread guides, the yarn passing directly from the rolls to the tip of the spindle. The yarn wraps several times around the spindle, then passes through the traveler, and finally winds into a package on the lower part of the spindle. At each revolution of the spindle, the coil of yarn nearest the top slips off over the tip, as in ordinary mule spinning, according to *Textile World*.

MODERNE design 8-in. oscillating fan developed by Robbins & Meyers. The finish is dull silver, and the oscillating mechanism is masked to eliminate catching of draperies

LIGHT-WEIGHT PROPELLER-TYPE blowers developed by the Coppus Engineering Corporation for expelling carbon monoxide gas in manhole work utilize stationary guide vanes of peculiar design beyond the propeller. The air current leaving the propeller is radially subdivided by the individual guide vane blades and taken up by them without shock. The blades have a curvature increasing in the direction of rotation of the propeller which results in concentration of the air current and gives it a further acceleration inside of the stationary vanes so that a considerable part of the pressure is produced in the latter. A large part of the end thrust is thus taken up by the stationary guide vane casing.

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ROLL GRINDERS, now being produced by Cincinnati Grinders Inc., incorporate centralized control that enables the operator to exercise complete control over all functions from one small platform, and a simple and flexible cambering mechanism which enables rolls to be contoured. The camber bar itself, from which the contour is obtained, can be either of permanent form or can be made from a parallel deep-section bar of hardened and ground steel which is sprung and clamped in the sprung position to meet the particular requirements of the roll being ground.

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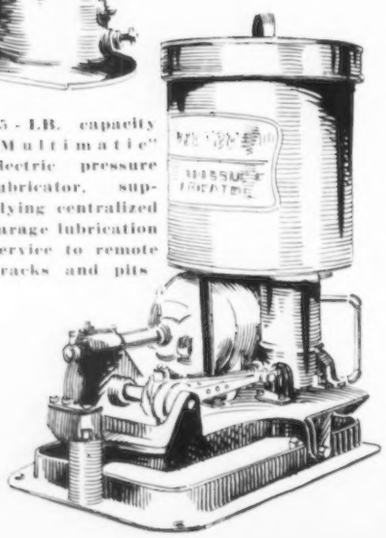
12-TON "Silver King" hydraulic bus jack, with depressed height of 12¾ in., extended height of 20 in., an example of the new low-height, high-capacity jacks



75-LB. capacity "Multimatic" electric pressure lubricator, supplying centralized garage lubrication service to remote racks and pits

DESSERT SERVICES utilizing dishes designed to fit into the freezing trays of mechanical refrigerators are being manufactured by the Chase Brass & Copper Company. Plating is with pure silver on 18 per cent nickel-silver and finish is in satin gloss.

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STEEL-BACKED bearing metal for heavy-duty service has been developed by the Kalif Corporation. A thin layer of copper-lead alloy is welded to a steel backing. The resulting bearing is said to combine the physical properties of the finely grained copper-lead alloy to give a material with strength and a low coefficient of thermal expansion. The alloy contains about 25 per cent lead and is cast upon the steel back by a centrifugal process to form a homogeneous layer about $\frac{3}{32}$ in. in thickness. The alloy has six times the heat conductivity of ordinary babbitt, and about $3\frac{1}{2}$ times the heat conductivity of bronze.

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FOOD MACHINERY at this month's show includes the first "SeparEGGor" or egg separator, having 12 combination receptacles suspended from a revolving spider, supported on a pedestal and a base. The upper receptacle is saucer-shaped and has a pivoted, liftable rim. The lower receptacle is cup-shaped. Below these receptacles is a circular drip pan with openings leading to chutes for various egg parts. Arrangements are provided for separation and removal of bad and broken-yolk eggs. The machine is fabricated of cast aluminum and stainless steel and operates from the ordinary light socket, according to *Food Industries*.

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TUBULAR VIBRATOR conveyors, now being adapted to the handling of hot materials, have been water-jacketed by the Traylor Vibrator Company, according to *Engineering & Mining Journal*. Cold water, under pressure, is injected at the lower end of the tube and circulates the length of the tube. The warm water then circulates back along the top side of the tube. Thus, materials as hot as 2,000 deg. F. may be handled and cooled in quantities up to 200 tons per hour.

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AUTOGIRO-TYPE airplanes made by the Kellett Aircraft Corporation will differ materially from standard aircraft practice, according to *Aviation*. Built-up members of stainless steel will replace the usual torch-welded steel tubing. Members in fuselage structures will be built of rolled steel strips spot-welded. The ship differs from others of its type in that there is no fixed wing fitted to the forward part of the fuselage. Instead, the tailplane has been somewhat enlarged and placed directly under the rotor disk at the rear of the machine. Two distinct types of rotor systems have been built, one a 3-bladed articulated system, the other a continuous blade pivoted at its center and free to rock about that point in addition to its rotational movement.

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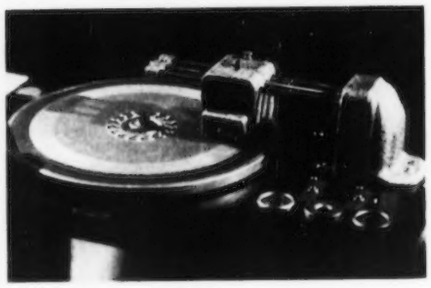
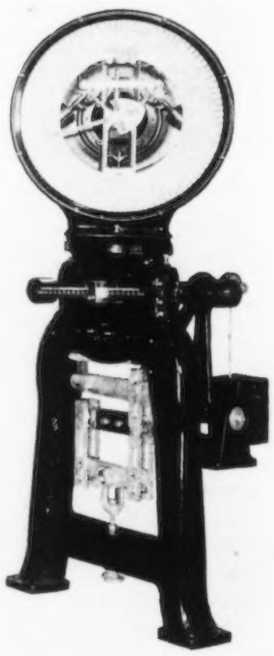
QUICK-FREEZING ice-cube trays for domestic refrigerators being produced by General Electric are of the "muffin-tin" type, each cube being frozen in its own individual mold, thus permitting the heat to be conducted away through the sides of each individual cube as well as on the bottom. The tray is of aluminum and has an aluminum cover.



CHROMATRON Recorder, utilizing a diamond needle to cut sound tracks on an aluminum alloy record. The needle exerts 350,000 lb. per sq.in. pressure at its point



TOLEDO Dynamometer Auto-Gage with remote control, operable either by extension links and levers or by a self-synchronous motor. The dial indicates total torque

Cruiser Types Favored At Motor Boat Show

THE trend toward smaller "family-type" cruisers was particularly noticeable at the Twenty-Sixth Annual Motor Boat Show in the Grand Central Palace, New York City, from Jan. 16-24. These boats range in price from $1,000 to $5,000 and accommodate four or more persons. Other cruiser types are of the high-speed commuter variety, making up to 42 m.p.h. More cruisers, engines, and accessories were on display than in any previous year, and the use of metals was also more pronounced, a Mullins runabout, for example, being made entirely of Monel metal. Streamlined hardware was prominent in the displays. The Johnson Motor Company showed a propeller drive unit for inboard motors which gives them the tilting feature familiar in outboards. The unit is so constructed that the propeller swings back when it strikes an object, and it also acts as a rudder. The Kennebec Canoe Company showed a similar device.

A number of Diesel engines were shown, the largest being a 20-ton, 8-cylinder model of 600 hp. displayed by the Cooper-Bessemer Corporation. The trend in motors is toward lighter, high-horsepower types, just as in automobile power plants.

Standards and Specifications

FEDERAL specifications released during the past month include No. 16 for paint thinner, No. 20a for liquid paint drier, No. 18b for water-resisting spar varnish, No. 7b for turpentine, and No. 67 for lithopone.

Eleven divisions of the S.A.E. Standards Committee presented reports covering new or revised standards at the annual meeting Jan. 19-23. Those deserving special mention are: dimensions of aluminum rivets, bolts, and nuts; extruded aluminum alloy sections; ball bearing lock washers and nuts; Diesel engine test forms; revision of No. 1112 S.A.E. steel screwstock specification increasing sulphur content to 0.10-0.18 per cent.

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News of the Metal Market

COPPER production, declining sharply in 1930, did not stem completely the price decline. A price of around 10c. on Jan. 15 brought slightly increased domestic and foreign sales, according to *Metal & Mineral Markets*. Though sellers claimed firmness at that level there are rumors of price cuts. Production will be further curtailed during the next several months, but consumers' wants have been fully taken care of and there is little expectation of a change in conditions.

ZINC, selling at around 4c. on Jan. 14, increased its sales with shipments evenly distributed over the first quarter. Domestic production is being curtailed sharply, but galvanizers and other user are still buying from hand to mouth, so that little change is expected.

LEAD prices, after a third drop since Jan. 5, settled at 4.75c., New York, on Jan. 8. Corroders and cable makers are principal buyers; babbitt and battery makers buying close.

Another Way of Obtaining "Appeal" in the Product

ONE COMPANY paid $10,000 to have an artist put sales appeal into its product; others have complete market research staffs to do the same work. The Westinghouse company has its own staff of artists, but asked the public to suggest designs for a beautified cabinet to house its radio. Forty-eight prizes, totaling $10,000, brought more than 60,000 suggestions.

Judges, here pictured, include: Left to right, sitting — Rosamond Pinchot; Helen Koues, Director of the "Good Housekeeping" Studio— standing, l. to r.—Neysa McMein, famous artist; E. B. Ingraham, Vice-president, Times Appliance Company, Inc.; A. W. Robertson, Chairman of the Board of Westinghouse; and Raymond Loewy, Parisian artist and designer.

IN THE SPOTLIGHT—

WILLIAM R. WEBSTER, vice-president and director of the Bridgeport Brass Company, will head the A.S.M.E. Research Committee during the coming year. He has been active in the brass industry for more than 35 years. His colleagues on the committee are W. H. FULWEILER, chemical engineer of the United Gas Improvement Company, ALEX D. BAILEY, superintendent of generating stations, Commonwealth Edison Company, and A. A. POTTER, Dean of the Schools of Engineering, Purdue University.

ALEXANDER P. BARTUSCH, formerly designer with S. Diescher & Sons Company, Pittsburgh, has become a mechanical engineer and designer in rolling-mill equipment with the Dneprostal Metallurgical Works, Pittsburgh.

HERMAN BOYSEN, formerly with the American Cirrus Engines, Inc., Marysville, Mich., has become a layout draftsman for the Reo Motor Car Company, Lansing, Mich.

FREDERICK F. BRAND has been appointed managing engineer of the Power Transformer Department, General Electric Company, Pittsfield, Mass., to succeed F. W. Peek, Jr., recently appointed chief engineer of the Pittsfield Works.

PROF. A. G. CHRISTIE, professor of mechanical engineering, Johns Hopkins University, Baltimore, Md., will speak on "Modern Steam Power Plants" at the Jan. 30 meeting of the Ontario Local Section, A.S.M.E.

HOWARD C. MARMON, vice-president in charge of engineering of the Marmon Motor Car Co., received the S.A.E. award for the year's most noteworthy automotive accomplishment in the development of passenger cars. He designed the 200-hp. all-aluminum engine in the new Marmon 16.

DR. HARRY A. CURTIS, chairman of the division of chemistry and chemical technology of the National Research Council, has been appointed chief of the Research Laboratories, Vacuum Oil Company.

M. C. DAVISON, assistant chief engineer of the Ingersoll-Rand Company, will deliver a paper on "Compressed Air" at the Pottsville Meeting of the Anthracite-Lehigh Valley Section of the A.S.M.E. on Friday, Jan. 30.

F. W. PEEK, JR., has been appointed chief engineer of the Pittsfield (Mass.) Works of the General Electric Company, according to a recent announcement by E. A. Wagner, manager. Mr. Peek succeeds Giuseppe Faccioli, who retired from active participation a few months ago because of ill health. Mr. Peek was previously consulting engineer.

W. E. ENGLAND, formerly chief engineer of the F. B. Stearns Company, Cleveland, has been added to the engineering staff of the Houde Engineering Company, Buffalo.

P. B. EATON, Associate Professor of Lafayette College, Easton, Pa., has been promoted to full professorship in the Department of Mechanical Engineering.

T. S. FULLER, metallurgist of the General Electric Research Laboratories, Schenectady, N. Y., discussed metallurgical problems of the electrical manufacturing industry before the New York Chapter, A.S.S.T., on Jan. 12.

A. W. HERRINGTON was recently named chairman of the Military Motor Transport Advisory Committee of the Society of Automotive Engineers. Other appointees include B. V. BACHMAN, W. T. FISHLEIGH, G. A. GREEN, F. C. HORNER, A. F. MASURY, O. A. PARKER, A. J. STAISE, W. J. DAVIDSON, F. K. GLYNN, J. E. HALE, H. O. HORNING, G. L. MCCAIN, V. G. ROOS, and A. W. SCARRATT.

William Webster

Howard Marmon

F. W. Peek, Jr.

L. H. GRISELL, formerly chief engineer for the Scripps Motor Company, Detroit, has become sales manager. He will retain supervision of the organization's engineering activities.

CHARLES R. HORTON, formerly layout draftman and inspector of aircraft woods for the Spartan Aircraft Corporation, Tulsa, Okla., has become production engineer with the Jackson Engineering Corporation, also of Tulsa.

T. MCLEAN JASPER, director of research for the A. O. Smith Corporation, Milwaukee, gave an illustrated lecture on problems in the construction and testing of high pressure pipes and other vessels before the technical club of Madison, Wis., on Jan. 5.

HARRY V. JOHANSEN, experimental and sales engineer for the Jones Clutch & Gear Company, Inc., Upper Sandusky, Ohio, has become a general sales representative, with offices in the General Motors Building, Detroit.

RAYMOND D. KELLY, formerly in charge of the engineering department of the American Paulin System, Inc., Los Angeles, now has charge of the instrument department for the Boeing Air Transport Company, Inc., Cheyenne, Wyoming.

HARRY W. KING, head of the engineering department, Morgan Engineering Company, resigned recently to become assistant vice-president of the Aetna-Standard Engineering Company, Youngstown, Ohio. Mr. King served many years as assistant to C. L. TAYLOR, formerly vice-president of the Morgan Engineering Company, and now will rejoin Mr. Taylor at Aetna-Standard in the same capacity.

P. J. MCINTYRE, who for the past seven years has been associated with the Wolverine Tube Company as research and chief engineer, has resigned to open an office under the name of the McIntyre Engineering Company, 403 W. Baltimore Ave., Detroit, Mich. He will devote his time to consulting engineering capacities on brass and copper tube products and production machinery for this class of work.

CLIFFORD F. MESSINGER has been elected president and general manager of the Chain Belt Company of Milwaukee. He was vice-president and general manager previously, and succeeds C. R. Messinger as president.

R. L. PEARSON, formerly chief engineer, has been appointed assistant to the general manager of the New York, New Haven & Hartford Railroad Company, New Haven, Conn. E. E. OVIATT succeeds Mr. Pearson as chief engineer. A. L. BARTLETT was named engineer of maintenance of way, and W. T. DORRANCE was appointed assistant to the chief engineer.

C. W. OBERT, consulting engineer of the Union Carbide & Carbon Research Laboratories, Long Island City, N. Y., led the discussion on "Proposed Specifications for Fusion Welding of Unfired Pressure Vessels" at the joint meeting on Jan. 22 of the Metropolitan Section, A.S.M.E., and the New York section of the American Welding Society.

G. A. ORROK, consulting engineer of New York City, will give a talk on "High Pressures and High Temperatures in Central Stations and Industrial Plants" before the Cleveland Section, A.S.M.E., on Feb. 2.

MANFRED RAUSCHER has become assistant professor of aeronautical engineering at the Massachusetts Institute of Technology, Cambridge, Mass. He was previously chief engineer of the Engineers' Aircraft Corporation, Stamford, Conn.

IRVING J. REUTER, who for the last four years had been president of the Olds Motor Works, Lansing, Mich., has become president and general manager of the Oakland Motor Car Company, Pontiac, Mich. Mr. Reuter was at one time a design draftsman for the Overland Auto Company, later chief engineer for the Remy Electric Company, and also president of the same company.

FRANK P. SERVAIS, formerly chief engineer of Silentbloc, Inc., New York City, has become vice-president of Vereinigte Servais Werke, A.G., Witterschlick b. Bonn, Germany.

H. A. SOULIS, formerly chief engineer of the Fruehauf Trailer Company, Detroit, has become a design engineer in charge of trailer design for the International Motor Co., Allentown, Pa.

C. R. MESSINGER, president of the Chain Belt Company, Milwaukee, Wis., has been elected to the presidency of the Oliver Farm Equipment Company, according to an announcement by J. E. Oliver, chairman of the board of directors of the Oliver Company.

H. L. SPAUNBORG, factory manager, the Bristol plant, Veeder-Root, Inc., Hartford, Conn., has been named chief engineer of the company and all engineering facilities will be consolidated at Hartford.

VINCENT BENDIX has assumed office as president of the S.A.E. Vice-presidents include ARTHUR NUTT, W. F. JOACHIM, L. R. BUCKENDALE, E. S. MARKS, C. B. PARSONS, A. K. BRUMBAUGH, and F. K. GLYNN.

EDWIN F. STOREY, formerly designer with Graham-Paige Motors Corporation, Detroit, has become a member of the engineering department of the Packard Motor Car Company, Detroit.

CHARLES STUMHOFER, formerly chief draftsman with the Salisbury Axle Company, Toledo, has been appointed assistant chief draftsman of the Toledo plant of the Spicer Manufacturing Company.

DR. ROBERT C. WILLIAMS has been appointed a member of the technical staff, Battelle Memorial Institute, Columbus, Ohio.

H. O. STEPHENS, I. H. SCLATER, and A. B. HENDRICKS, JR., have been appointed assistant engineers of the power transformer department, General Electric Company, Pittsfield, Mass., of which F. F. Brand is managing engineer. Mr. Stephens will be in charge of the design of oil-immersed transformers over 7,000 kva., air-blast transformers, reactors and starting auto-transformers. Mr. Sclater will have charge of the design of oil-immersed transformers from 501 to 7,000 kva., oil-immersed current and potential transformers, radio power and SI. transformers. The design of all developmental and high-voltage testing apparatus will be in charge of Mr. Hendricks.

C. A. THAYER, formerly chief engineer for the Arthur G. McKee & Co. steel works project in Soviet Russia, has been appointed chief engineer of the Republic Steel Corporation, Youngstown, Ohio.

HAROLD G. TRAVER has become a mechanical engineer with Keasbey, Mattison & Company, Ambler, Pa.

JOHN E. WEISS, formerly layout man and detailer for the Curtiss-Wright Aeronautical Corporation, Paterson, N. J., has assumed a similar position with the Lawrence Engineering & Research Corporation, New York City.

R. R. WEDDELL, formerly chief engineer of the O. K. Tool Co., Shelton, Conn., has been appointed sales manager. E. Reaney will succeed Mr. Weddell as chief engineer. OLE SEVERSON has been placed in charge of all development and research work and will be succeeded as production manager by A. CURRY.

C. R. Messinger

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Vincent Bendix

●

HORACE E. WEIHMULLER, previously president of the Corman Aircraft Corporation, Dayton, Ohio, has become connected with the airplane division of the Ford Motor Company, Dearborn, Mich., as aeronautical engineer.

Obituaries

HENRY A. HOUSE, 90, famous inventor, who in 1866 built the first American steam automobile, died at Bridgeport, Conn., on Dec. 18. He had taken out more than 300 patents.

WILLIAM FLETCHER BARNES, 89, inventor of a clutch which solved difficulties of development of off-center principle machinery, founder of the W. F. & John Barnes Company, Rockford, Ill., in 1873, died on December 28 in Rockford.

WILLIAM S. BARTHOLOMEW, 77, a leader in the development of mechanical stokers for locomotives, died in Pittsburgh on Jan. 6. Before his retirement three years ago, he was head of the Locomotive Stoker Company, a subsidiary of the Westinghouse Air Brake Company, and a vice-president of the latter.

WILLIAM C. FARNUM, 81, manufacturing executive and noted inventor, died at Fitchburg, Mass., on Jan. 6.

ALBERT S. JANIN, 51, inventor of several types of airplanes and various airplane elements, died on Jan. 7 in New York City after a long illness.

ALAN R. MCFARLAND, 60, chief engineer of the Solvay (N. Y.) Process Company, for 31 years, died recently at his home in Syracuse, N. Y., following a brief illness.

GROVER M. SPERRY, 58, president and general manager of the Sperry Machine Shop Company, LeRoy, N. Y., and widely known as a machine engineer, died recently at his home in that city after a heart attack.

ANDREW TURNBULL, 98, inventor of weighing scales and a number of other metal products, died in New Britain, Conn., on Dec. 22.

Meetings

Steel Founders' Society of America—Annual Meeting and Election, January 29, Hotel Hollenden, Cleveland, Ohio. G. P. Rogers, Managing Director, 932 Graybar Bldg., New York City.

Fifth Midwestern Power & Engineering Conference and Exposition—Chicago, Feb. 10-14. G. E. Pfisterer, 53 West Jackson Blvd., Chicago, secretary.

Western Metal Congress and Exposition—Second National, Civic Auditorium, San Francisco, Calif., Feb. 16-20. Under auspices of A.S.S.T., W. H. Eisenman, secretary, 7106 Euclid Ave., Cleveland, Ohio.

Steel Founder's Society of America—Sales clinic and regular meeting, March 19-20, Neil House, Columbus, Ohio. G. P. Rogers, Managing Director, 932 Graybar Bldg., New York City.

NEW MATERIALS AND PARTS AND ENGINEERING EQUIPMENT

Stephens-Adamson Variable-Speed Drive with Integral Motor

A VARIABLE-SPEED drive, which combines a motor, speed changer, speed reducer, and control in a single housing, has been designed by the Stephens-Adamson Manufacturing Company, Aurora, Ill. This drive is very compact, easily mounted, quiet, and is claimed to be efficient because of the elimination of bearings, couplings, and at least two sets of gear reductions. It is made in sizes to deliver from $\frac{1}{4}$ to 7.5 hp. to feeders, assembly conveyors, mixers, machine tools, textile machinery, pumps and other applications where variable-speed drive is required.

The unit, as shown in Fig. 2, is a complete drive in itself, and is ready to couple to the machine to be driven. The motor section is usually wound to operate at 1,200 r.p.m. and gives speeds between 24 to 144 r.p.m. or 120 to 720 r.p.m. The output speed is increased or decreased while the machine is in motion by simply turning the small handwheel on top of the housing. The unit can be mounted in any position.

This drive is essentially the standard "JFS" type of variable-speed reducer with the housing modified to take the body of a standard make of electric motor. The motor armature shaft is extended and forms the high-speed shaft of the speed changer. In this way the usual coupling is eliminated.

Operation of the speed changer section is simple and positive. As shown in Fig. 2, the motor shaft rotates two inner races. These races cause three double conical rollers to rotate slowly in planetary fashion inside the two outer races, which are held from turning. The three planetary rollers drive the variable-speed shaft through a spider. The output speed can be decreased or increased to any rotation by turning the handwheel, which moves the two outer races farther or nearer apart. As the two races approach each other, the three rollers are forced toward the center and in turn push the two inner races apart against heavy springs, which maintain the pressure necessary for driving traction on the two outer races.

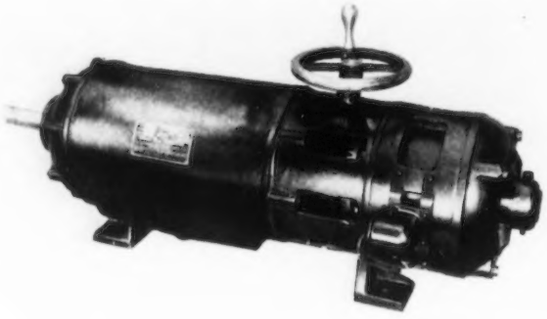


Fig. 1 — Stephens-Adamson Variable-Speed Drive, consisting of a variable-speed reducer, an electric motor and a speed control

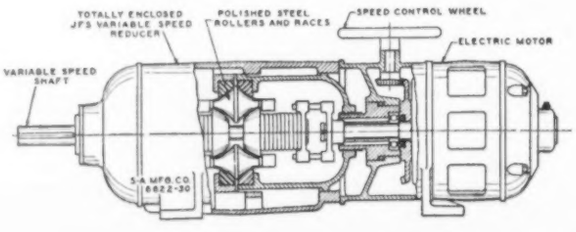


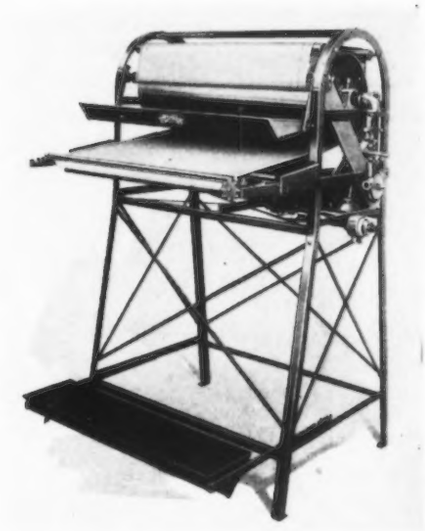
Fig. 2—By turning the handwheel, the rotation of the variable-speed shaft of the Stephens-Adamson Variable-Speed Drive can be regulated to any speed wanted

Allis Air-Brake Motor Starter

AN air-break "explosion-proof" motor starter, known as the Type E, Form AAA, has been developed by the Louis Allis Company, Milwaukee, Wis. This starter is built to prevent the escape of flame from any explosion likely to occur inside the apparatus due to grounds and burn-outs. The starter proper consists of the usual across-the-line, air-break, magnetic contactor with overload and undervoltage protection. Strength to withstand explosions is provided by a very heavy cast-iron case, the cover being held on by 10 heavy capscrews. It is therefore approved for use in Class I. Group D hazardous locations.

Pease "Junior" Sheet Dryer

AN inexpensive sheet dryer for the production of blueprints and photocopy prints quickly and at low cost, and intended for those who do not require a large machine, has been placed on the market by the C. F. Pease Company, 813-821 North Franklin St., Chicago, Ill. It has capacity for prints up to 24-in. wide and is simple to operate.



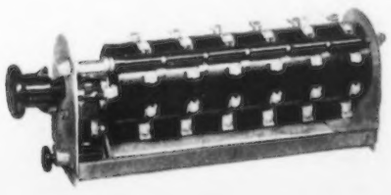
Pease "Junior" Sheet Dryer

Prints are fed into the dryer over a brass scraper rod and up an inclined feed table, which drains the water away from the drying drum and prevents steam pockets and creased prints. Surplus water is collected in an adjustable drip pan. After drying, the prints are automatically returned to an adjustable tray at the front of the machine, but when especially long prints are being run, the tray can be pushed back out of the way.

The revolving copper drying drum can be furnished with either gas or electric heating elements, and may also be chromium plated, when so specified, for photo prints. The Pease "Junior" sheet dryer is equipped with a $\frac{1}{8}$-hp. motor and variable gear drive for two speeds, either 2 or 3 ft. per minute. Over-all height is 5 ft. 3 in., and floor space is 3 ft. 5 in. by 3 ft. 6 in.

General Electric Switches for Changeable-Pole Motors

TWO switches for use with multi-speed, changeable-pole motors have been announced by the General Electric Company, Schenectady, N. Y. These switches bear the designations CR-2960-SY-108 and SY-113, having maximum capacities of 5 hp. and 10 hp. These switches, when used with multi-speed, squirrel-cage, induction motors, permit obtaining different speeds by changing the polar grouping of the stator coils.



For small motors one of these switches will serve as a starting switch, as well as a pole-changing switch. Both switches can be used with two-, three- or four-speed motors for constant-horsepower or constant-torque service without change in mechanical construction.

Ditto Copying Machine

AN improved Ditto machine, suitable for reproducing specifications, contracts, drawings and sketches, has been placed on the market by Ditto, Inc., Harrison and Oakley Blvd., Chicago, Ill., Detailed drawings can be reproduced neatly at a cost of five to ten cents per hundred. Forms needed only in small quantities can also be produced economically.

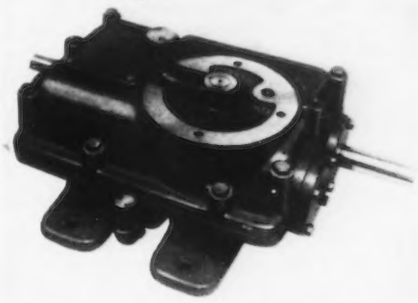
The original record may be a drawing, a hand written memorandum, or typewritten or printed sheet. In all cases a special Ditto ink, pencil, or typewriter ribbon must be used. The machine makes copies by transferring ink, which may be had in colors, direct from the original to a duplicating composition, which dissolves and holds the ink on its surface. This copying surface is mounted on a cloth backing, 14½ ft. long, which can be rolled upon two rolls. Within a few hours the duplicating composition absorbs the impression and can be used again.

The main features of the machine are the two side frames supporting a flat steel bed over which travels a feeding carriage, which lays down the blank sheet and picks up the copy.

The machine is made in four standard sizes: C, K, L and M with sheet capacities from 8½x14 to 22x34 in. Special sizes are also available.

Adams Multi-Speed Reducers

THE variable speed reduction box, developed by The Adams Company, Dubuque, Iowa, differs from the conventional type of speed reducer in that it combines in one housing a speed reduction and a sliding gear box mechanism, making the unit adaptable to any piece of equipment which it is desired to drive from a constant-speed motor, and yet on which a variation in output shaft speeds is necessary. This unit incorporates four speed changes, which are obtained through a single shift lever. The gears are of carburized and hardened steel, with the teeth of the sliding gears rounded to facilitate engagement. The shafts are of alloy steel and are mounted on Timken tapered roller bearings. An oil level is maintained to keep the entire unit properly lubricated.

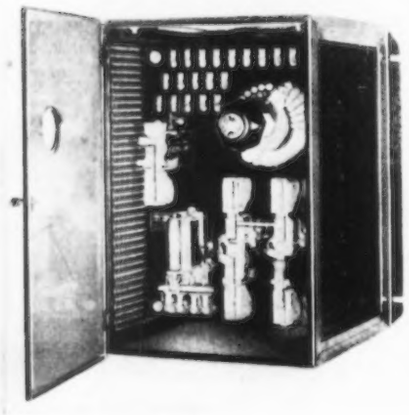


On the standard unit, the input and output shafts are in line, but when necessary, units can be furnished for right-angle drive. A wide variety of speeds and horsepowers are obtainable for each of the sizes of standard housings.

Monitor Printing Press Controllers

CONTROLLERS for the printing industry, comprising a.c. and d.c. controllers for automatic, high-speed self-feeding presses, folders, paper box-making machines, and similar machinery, have been announced by the Monitor Controller Company, Balti-

NEW MATERIALS AND PARTS



Monitor Printing Press Controller providing automatic starting, pre-set speed, magnetic reversing, and automatic braking

more, Md. These controllers furnish automatic starting, pre-set speed, magnetic reversing, and automatic braking.

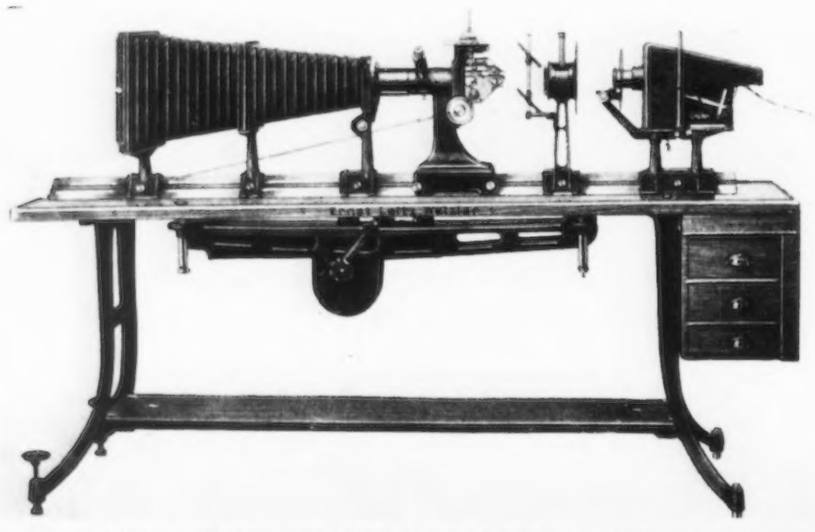
The d.c. equipment consists of a main and a blower motor controller mounted on one panel, one or more operator's stations, and when required for interlocking with the press, a slow-down or trip station. The a.c. outfit has the same features, except that an automatic brake switch is added.

Leitz Improved Micro-Metallograph

HEAVIER design to give increased rigidity is now employed in the micro-metallograph built by E. Leitz, Inc., 60 East 10th St., New York, N. Y. The object stage is of increased dimensions, and because of its solid mounting to the microscope, affords correct mechanical motion to the specimen. The fine adjustment is encased in a separate housing protecting the micrometer screw from thermal efforts to insure maintaining the focus of the objective. A circular reflecting mirror surrounds the tube.

By employment of Periplan eyepieces, increased flatness of the micro-image is obtained. A special optical unit is built into the vertical illuminator. The iris diaphragm, after being placed off-center for oblique illumination, may be rotated so that the angle of obliquity may be made to exist at any azimuth. Thus, adjusting the azimuth of the illumination with respect to the direction of the specimen structure is made possible.

The Leitz Micro-Metallograph can also be used for photographic study under transmitted, ordinary or polarized light.



Increased flatness of the image is obtained on the Leitz Improved Micro-Metallograph

"Chemical" Metallographic Polishing Machine

POLISHING of metallographic specimens on the automatic machine developed by The Chemical Rubber Company, Cleveland, Ohio, is not dependent upon the operator's ability. It automatically produces a plane surface with a high quality polish. The machine consists essentially of a polishing disk mounted horizontally on a duraluminum casting. This casting is attached rigidly to a cast-iron table.

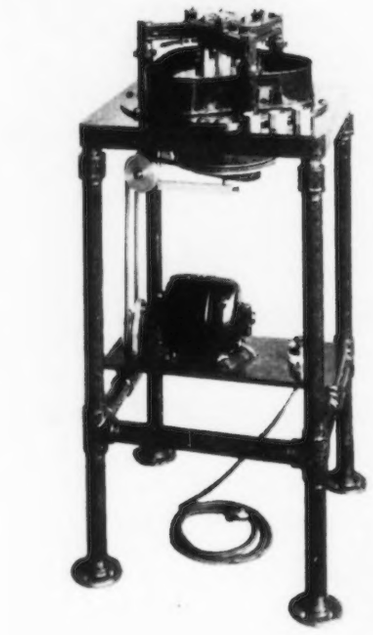


Fig. 1—"Chemical" Automatic Metallographic Polishing Machine for specimens up to 1 in. in diamter and 1 in. high

Fig. 2—Showing the three specimen arms and sleeves together with the polishing disk

The polishing disk is belt driven by means of a ¼-hp. motor and rotates at 400 r.p.m. Passing vertically through the shaft carrying the polishing disk is a second spindle, to which is attached an eccentric gear as shown in Fig. 2. This eccentric gear drives the specimen holders, of which there are three, in such a way that the specimen is slowly moved back and forth along the radius of the turning disk. At the same time the specimen is rotated slowly so that the direction of polishing is changed continually. By means of a gearbox having a ratio of 100 to 1, the specimen is caused to revolve at 4 r.p.m. This rotating movement of the specimen prevents pitting and the formation of "comet

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tails" at inclusions in the specimen.

In this machine all specimens must be mounted. The holders in Fig. 2 accommodate specimens up to 1 in. in diameter and 1 in. high.

Sterling Motors with Herringbone Rotors

MOTORS from 1 to 50 hp. are now built by Sterling Electric Motors, Inc., Telegraph Road at Atlantic Blvd., Los Angeles, Calif., with herringbone rotors to achieve quiet operation. These motors therefore are suitable for duty where quiet performance is important.

Among the features of these motors brought about by the herringbone rotor shown in Fig. 2 are: noiseless operation; no end thrust and resulting wear on bearings; no back and forth lateral pounding; no circulating currents; improved pull-out efficiency and power factor; and reduced starting current, heating, eddy currents,

Fig. 1—Sterling Motor employing a herringbone-type rotor in sizes from 1 to 50 hp. to achieve quiet operation

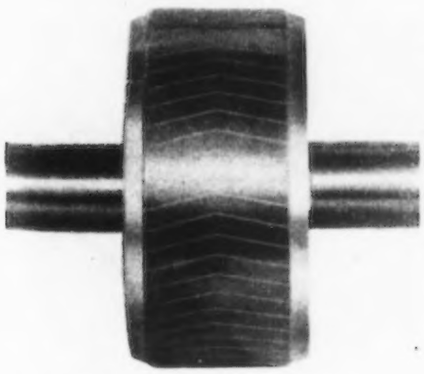
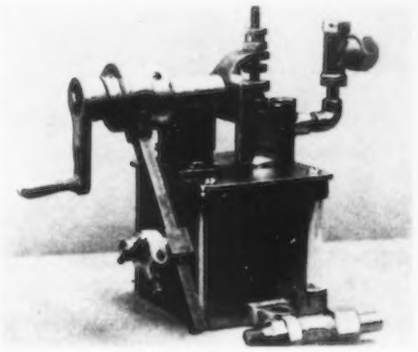


Fig. 2—Showing the herringbone slot construction of the motor

and iron losses. Mica and asbestos are built into the motor windings, minimizing the danger of breakdowns.

Hills-McCanna Improved Lubricators

THE "K-K" (Kam-Klutch) drive or the ratchet type of driving mechanism can now be obtained on the lubricator built by the Hills-McCanna Company, 2349 Nelson St., Chicago,



Ill. The "K-K" mechanism comprises a right-hand part which attaches to the standard for the purpose of holding the crankshaft when on the back stroke, and a left-hand part which attaches to the driving rod operating the crankshaft on the forward stroke.

A Kam-Klutch is comprised of spring-held rollers embodied in a housing to work with and against the crankshaft when operating. The drive permits attachment to the high speed-driving arms in any position within a complete circle, and likewise gives the lubricator greater speed in oil delivery. This drive is interchangeable with the present ratchet drive. Another feature is the improved charging arm or crankshaft for flushing cylinders when starting up or for increasing the flow.

Monitor Push-Button Switch

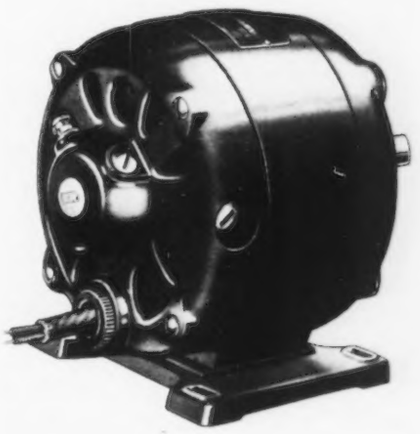
FOR momentary contact control, especially on machine service, the Monitor Controller Company, Baltimore, Md., has designed an ironclad push-button switch for a.c. or d.c. circuits. Features of this switch include quick-action inching, massive and flexible contacts, and buttons located for safety. The stop button is on the top, fully exposed and easy to operate. The start button is placed below and fully protected from accidental contact. The switch is both drip- and splash-proof.

The switch consists of two parts:

(1) the base which carries the wiring and fixed contacts, and (2) the cover carrying the buttons. Conduit connections can be made from top, bottom, or sides. The over-all height is $4\frac{1}{4}$ in., width, $2\frac{13}{16}$ in., and depth from mount $2\frac{5}{8}$ in

Bodine Type N-5 Motors

THE Bodine Electric Company, 2254 W. Ohio Street, Chicago, Ill., announces Type N-5 fractional horsepower motors, which will ultimately replace the older Bodine Types SA and SD motors. Two frame sizes of



the Type N-5 are now in production, having ratings of $\frac{1}{30}$ and $\frac{1}{12}$ hp., respectively, at 1,125 r.p.m. and $\frac{1}{16}$ and $\frac{1}{8}$ hp. at 1,725 rev. per minute.

The Type N-5 frame is equipped with specially developed wool-packed bearings. A leaded bronze bearing is used and it is provided with double oil slots at the sides, giving double contact areas for the wool packing.

By using a larger fan and larger

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ventilating ducts on the stator, the ventilation has been increased considerably so that increased ratings for a given frame size range from 15 to 30 per cent as compared with the older Types SA and SD frames.

Vickers Hydraulic Pump

HIGH volumetric efficiency, continuous working pressure at 500 lb. per sq.in., or to 1,000 lb. per sq.in. for press work, high mechanical efficiency, and long life with quiet operation are features of the V-type rotary pump being placed on the market by Vickers Incorporated, 7752 Dubois St., Detroit, Mich. The capacities of the two sizes available are 15 and 30 gal. per min. at 1,000 r.p.m. The pumps are for use in all machinery where hydraulic control or hydraulically controlled mechanisms are desired.

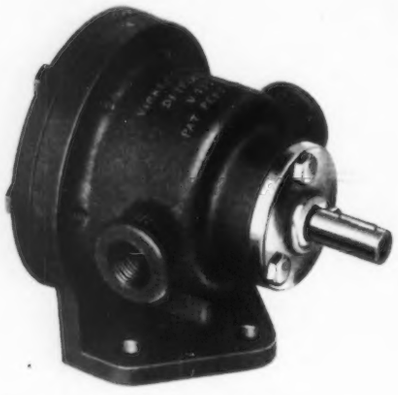


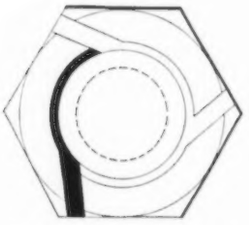
Fig. 1— Vickers Hydraulic pump, available in two sizes, 15 or 30 gals. per min. at 1,000 r.p.m. and 1,000 lb. per sq. in. for hydraulic control of machine mechanisms

The pump shown in the illustrations requires small installation space in proportion to its capacity. All parts can be readily removed from one end without disturbing the set-up or the piping. The rotor and ring are of Nitralloy hardened and ground, and the port flange and bearing flange are of hydraulic bronze. The harmonic curve in the ring at the ports, which joins the concentric curve at the ends, gives a balanced pressure on both sides of the vane, thus eliminating unevenness in flow and increasing the mechanical efficiency. A cork gasket forms a seal between the flange and the removable end plate. The casing is of special high-test nickel cast iron. Parts are interchangeable, and larger capacity can be gained by changing the internal parts.

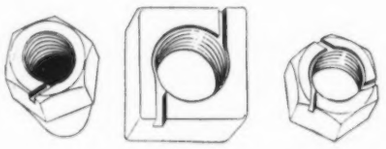
Mechanical efficiency of the pump is from 82 to 86 per cent, and there is no appreciable drop in efficiency at high pressures. The volumetric efficiency at 500 lb. per sq.in. delivery pressure is approximately 98 per cent. Weight of the pump is 31½ lb.

Kraberhall "Safety-Nuts"

LOCKING by means of a triangular pin driven in a channel and along the root of the thread for a short distance is the principle employed in the "Safety-Nuts" marketed by Kraberhall, Inc., Land Title Bldg., Philadelphia, Pa. The triangular pin is about the size of a nail. When the nut is in place the pin is gently tapped into one of the channels to meet the thread. It then progresses between the threads and turns to conform to the arc of the bolt. As it advances, it finally passes a small hump or offset in the nut channel placed there to retard possible relaxation of the spring action of the pin. The nut can be backed off with an ordinary wrench, the pin coming loose. The nut can be put on and removed a great many times without causing damage to the threads.



Hex "Safety-Nut" having three channels for the insertion of a triangular locking pin.



Types of hot-pressed "Safety-Nuts" available

The particular application of the "Safety-Nut" is for bolts subjected to severe vibration, such as found on riveting guns. It is satisfactory for this class of service, as well as other equipment not subjected to such severe requirements.

It will be apparent that any nut of this type of the same height as the standard nut will have fewer effective threads. To overcome this, two sizes have been developed, one of the same height as the standard nut, and one that is sufficiently higher so that it contains the same number of threads as the standard nut. The "Safety-Nuts" are available in any size, style or finish, at a cost comparable to that for nuts using cotter pins.

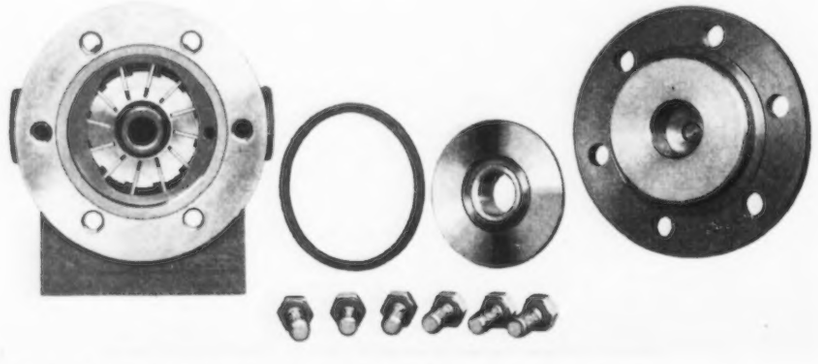


Fig. 2—Components of the Vickers Hydraulic Pump, showing in particular the cross-section of the pumping chamber and the numerous vanes employed to get smooth flow

"No-Ink" Drawing Board Top

SMOOTH, resilient surface for the production of pencil drawings suitable for reproduction purposes is afforded by the "No-Ink" drawing board top manufactured by W. H. Long Company, 420 N. Clark St., Chicago, Ill. This composition material is white, stain-proof, scratch-proof, and washable. Its use requires no change in equipment. The material comes in

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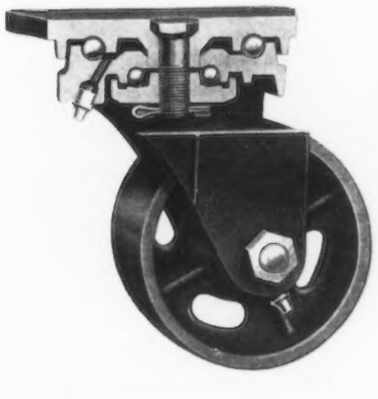
any size sheet $\frac{1}{8}$ in. thick and the top edges are slightly rounded. It can be glued or fastened to old boards, and the life with ordinary use is estimated at from 8 to 10 years.

No manila paper is used with the "No-Ink" drawing board top. The regular drawing paper is attached directly to the surface and a 3-H or harder pencil is used. All lines are drawn with a double stroke and with a slight pressure on the pencil. The pressure of the first stroke ridges the paper, and the back stroke fills in the valley evenly with lead. The result is a solid, opaque, even-edged line, reproducing clearly on blueprints, Van Dykes and other process papers. Changes can be made in any line by the usual rubbing out process, and the ridges or valleys will not show on reproductions. Because of the resiliency of the board, the indentations in the surface made by the pressure of drawing tools disappear immediately. Because of hard lead deposited in a valley, the lines do not smudge when worked over for any length of time, and hence these drawings can be taken out of file at any time and readable prints made of them.

Buffalo Swivel Casters

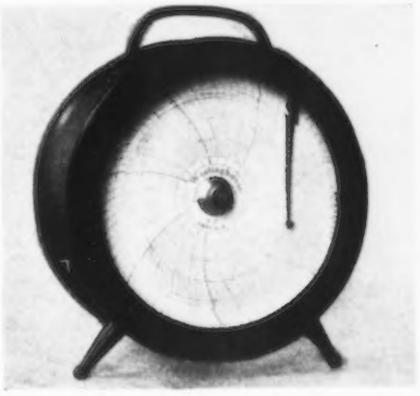
SEVERAL swivel-type truck casters have been placed on the market by the Buffalo Pulley & Caster Company, Inc., 182 Breckenridge St., Buffalo, N. Y. The first is a 3-in. swivel caster with a large plate and overhanging lip. It has an over-all height of $4\frac{1}{4}$ in., and the model number is 303-N. Another 2-in. swivel caster has also been placed on the market. This caster, the No. 200-NS, has a 2-in. wheel having a $\frac{3}{4}$-in. face, and the oblong plate is 2x3 in. This type of caster is also available in $2\frac{1}{2}$, 3, $3\frac{1}{2}$, 4 and 6 in. wheel diameters, the last being with a single ball race. In the double ball race caster an overhanging lip is also provided on the plate. The 2-in. caster, mentioned above, is also made with a thread guard.



Buffalo Model 404-WR Truck Caster, which has double ball race construction and an overhanging lip on the plate

Westinghouse Recording Instruments

AMMETERS and voltmeters in small, light, recording types have been placed on the market by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. These



Westinghouse Type A Circular Chart Recording Voltmeter for portable use

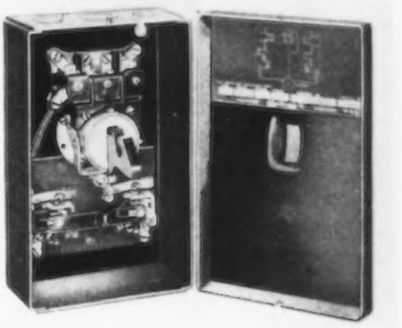
instruments, designated as Type A, are made for switchboard mounting or as portable instruments. They are designed principally for a.c. applications, but are also applicable to certain d.c. services.

The ammeters are available in sizes ranging from 5 to 50 amp., and give a full-scale reading. The voltmeters are made with scales for 90 to 140 volts to scales reading to 550 volts.

Three kinds of clocks for moving the circular chart are provided: a key-wound, 8-day clock for driving the one-week charts; a key-wound, 36-hour clock for driving the one-day charts; and a sub-synchronous (self-starting) motor-driven clock, operated by the system frequency. Change gears are available for other speeds.

Allen-Bradley Bull. 609 A.C. Starter

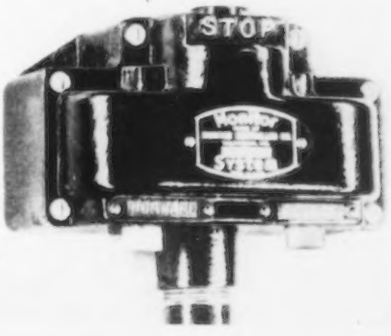
FOR motors of 3 hp., 110 volts; 5 hp., 220 volts, and $7\frac{1}{2}$ hp., 440-550 volts, the Allen-Bradley Company, 1311 S. First St., Milwaukee, Wis.,



has announced a hand-operated Bull. 609 starter with overload breakers. They are reset with a lever without opening switch cover. The switch can be padlocked in open position if required.

Monitor Push-Button Master Station

AN ironclad push-button master station has been added to the line of the Monitor Controller Company, Baltimore, Md. It is available for use in either a.c. or d.c. circuits to provide forward and reverse momentary contact control, and is particularly suited to machine service. This reversing station has massive and flexible contacts. The forward and reverse buttons are in a protected position at the bottom, and the stop button is placed at the top where it is easy to operate. This arrangement is adapted to give quick-action inching in either direction as desired.



NEW MATERIALS AND PARTS

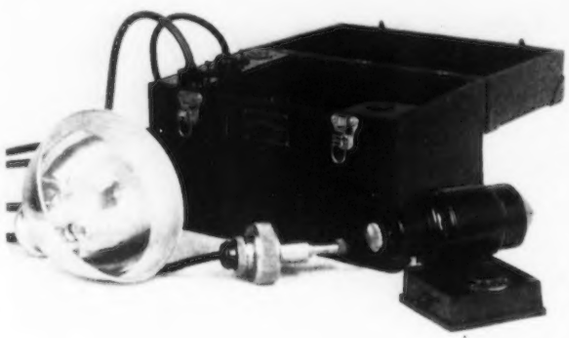
Electrocon Model 3 "Vibroscope"

STROBOSCOPIC action is employed in the Model 3 "Vibroscope" announced by the Electrocon Corporation, 6 Varick St., New York, N. Y. This model has five times the illuminating power of the Model 1, which has been on the market for some years. The motor unit is a new feature.

The Vibroscope is applicable to the study of rotary, reciprocating, or vibratory motions, and in fact, to any type of motion that occurs in repeating cycles, and provided that the hand lamp flashes in synchronism with the motion, or at a low multiple of it. Observations can be made comfortably in the normally lighted laboratory or shop on apparatus running at speeds from 40 to 12,000 r.p.m. The higher speeds can be handled by using the motor unit and running it at a low multiple of the speed of the equipment undergoing tests for performance.

The stroboscopic principle depends upon the interruption of vision between the operator's eye and the mechanism under observation so that he gets a quick glimpse of the mechanism each time it reaches a certain point in its cycle. The result of this quick succession of glimpses, at the same point every time, is to cause the mechanism to appear perfectly stationary at that point. This phenomenon is known as "persistence of vision." A hand neon lamp which produces brilliant light flashes of extremely short duration is used to illuminate the moving mechanism. It consists of an aluminum reflector, which is 8½ in. in diameter, and which houses three neon tubes. The breaker head is driven from the mechanism under observation, and is provided with a rubber and steel driving point such as found on a hand tachometer. An electrical circuit is broken once per revolution at a pair of cam-operated platinum points. A small knurled knob in the breaker head is known as a phase adjuster. By turning this, the neon tubes can be made to flash at different positions in the revolution, so that the moving mechanism may be viewed at different positions in its cycle. The angular position of a mechanism at a critical occurrence can be ascertained.

The Vibroscope forms a part of the Davey portable balancing equipment, but the Model 3 is a potential balancing equipment, being wired to accommodate the Davey Vibrometer, which must be added for that purpose.



"Vibroscope" Model 3 Stroboscope, which is provided with a lamp giving greatly increased illumination. Mechanisms can be studied at operating speeds from 40 to 12,000 cycles per min.

Shakeproof Self-Locking Setscrew

OFFSETTING the slotted end of the screw so that when inserted the sharp edges bite into the work and exert resistance to any backward movement is the principle employed in the self-locking setscrew recently announced by the Shakeproof Lock Washer Company, division of Illinois Tool Works, 2501 N. Keeler Ave., Chicago, Ill. The locking power can be varied to suit individual requirements. Where it is necessary to have a setscrew that can be removed easily, the degree of offset is reduced; where the product is exposed to intense vibration, the offset can be increased to insure absolute resistance against backing out.

It is said that once this self-locking setscrew is tightened down, it is impossible for vibration to loosen it. The biting action is very pronounced, even when a screw-driver is used to back it out. Aside from the ability to stay tight, and thus keeping parts functioning properly, the setscrew reduced assembly costs, since it eliminates the extra operation of staking it in position. The design principle of this setscrew is patented.

Exaggerated top view of the Shakeproof Self-Locking Setscrew

PUBLICATIONS

FOR THE ENGINEER'S LIBRARY

A.S.T.M. STANDARDS. The American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa., has issued the "Index to A.S.T.M. Standards and Tentative Standards" as of September, 1930.

CHAIN, SILENT AND ROLLER. The Union Chain & Manufacturing Co., Sandusky, Ohio, has available a 124-page catalog on silent and roller chain, giving the sizes available, engineering data, and information on sprockets and chain attachments.

FASTENINGS. The Parker-Kalon Corporation, 200 Varick St., New York, N. Y., is now distributing a booklet entitled "Fastenings—How they are made by leaders in the metal-working industries," giving a study of the use of Parker-Kalon self-tapping screws in several different industries and showing the reductions in cost.

MEASUREMENT OF SURFACE TEMPERATURES. The U. S. Department of Commerce, Bureau of Standards, has issued Research Paper No. 231 entitled "Measurement of Surface Temperatures." The paper describes a surface thermometer of the thermo-couple type. It is for sale by the Superintendent of Documents, Washington, D. C., for $0.10.

MOLDING COMPOUND. The Lumarith Division of the Celluloid Corporation, 10 East 40th St., New York, N. Y., has issued a booklet on "Lumarith," giving the physical and chemical characteristics of this cellulose-acetate molding compound.

PULLEYS. The Westinghouse Electric & Manufacturing Co., Pittsburgh, Pa., has issued publication D.M.F. 5300-A on Micarta control-wire pulleys of the self-lubricating and ball-bearing type for airplanes.

Chart for Transferring Moment of Inertia

FORMULAS and tables for the moment of inertia of the regular areas or bodies give the result about an axis, generally through the center of gravity. For irregularly shaped areas or masses the designer can find readily from tables the value for each unit area or mass about an axis through the center of gravity of the entire area or mass. The moment of inertia for each unit may then be found about any parallel axis by applying the following formula, the sum of the moments of inertia of the units, about a common axis, being that of the whole mass or area about that axis.

$$I = I_o + W X_o^2 \qquad \text{(Eq. 1)}$$

in which I = Moment of inertia of small mass or area about any desired axis in lb.-in.^{2} or in.^{4}.

I_o = Moment of inertia of small mass or area about the axis specified in the table, in lb.-in.^{2} or in.^{4}.

W = Weight of unit of body in lb., or area in sq.in.

X = Distance between specified axis and desired parallel axis, in in.

The chart on the other side of this page has been laid out so that the moment of inertia may be transferred from one axis to another without the necessity of arithmetical calculations. This chart is read by two perpendicular lines as shown by dot-dash.

The equation to be charted may be written:

$$I - I_o = \frac{X_o^2}{1/W}$$

Each of these four variables are to be plotted along a separate line. Having decided on the size of the chart, draw in pencil two parallel lines a distance apart about equal to the length desired for the scales. The exact distance is immaterial. From the upper end of the left-hand line draw a diagonal downward at any convenient angle, say 30 deg. Next draw a cross line near the bottom of the sheet at 90 deg. with the two parallel lines. This is the X_o scale shown on the chart. From the point of intersection of the left-hand vertical line and the cross line draw a line perpendicular to the diagonal cross line. This is the W scale on the chart. The diagonal is not shown on the finished chart because no scale is put upon it.

By geometry it can be shown that with this type of chart the following relations exist:

$$x = M_1 I$$
$$y = M_1 I_o$$
$$z = M_2 X_o^2$$
$$q = M_3 \left(\frac{1}{W}\right)$$

In these equations the x, y, z, and q are the distances from the beginning of each scale to the selected value for the variable. The letters M_1, M_2, and M_3 are the so-called modulae of the scales and may be given any value the designer wishes within reason and with certain limitations. As will be noted from the accompanying chart, I is plotted downward on the left-hand vertical line. This scale starts at the intersection of this vertical line and the diagonal. Similarly I_o is plotted downward on the right-hand vertical line beginning at the intersection of this line with the diagonal. The value of X_o is plotted from left to right on the cross line beginning at the intersection of this line with the left-hand vertical. W is plotted on the line drawn upward to the right and perpendicular to the diagonal. The scale on this line starts where it intersects the left-hand vertical. It will be noted that the values on this scale run the other way, but this is due to the fact that q in the above equation varies as the reciprocal of W.

Before the scales can be plotted, numerical values must be assigned to M_1, M_2 and M_3. The only limitation to the selection of numerical values for these constants is that the following relation must hold,

$$K = \frac{M_1 M_2}{M_3}$$

where K is the length in in. of the diagonal drawn between the two vertical scales. When K is fixed and the value for two of the constants has been selected, the third will follow. Sometimes it is best to select the three constants first and let K come as it will, then draw the diagonal accordingly.

When these constants, M_1, M_2, and M_3, have been selected so that practical scales will result, they can be substituted in the above equations for the scales and the scales actually plotted.

In the chart on the other side of this page, as originally laid out, the length of the diagonal or K was 10 in. The constants for the scale equations were selected as follows:

$M_1 = 0.1$ $\qquad$ $M_2 = 1$ $\qquad$ $M_3 = 100$

The equations for the scales then became,

$$x = 0.1\, I$$
$$y = 0.1\, I_o$$
$$z = 1\, X_o^2$$
$$q = 100 \left(\frac{1}{W}\right) = \frac{100}{W}$$

For plotting the scales, substitute different values of the variable, for example, I in the first equation, and for each such-selected value obtain a value for the distance in the first equation. Lay off this distance from the starting point of the scale, given above, and mark this point with the value of the variable. As many subdivisions of each scale may be made as desired.

Contributed by H. M. Brayton

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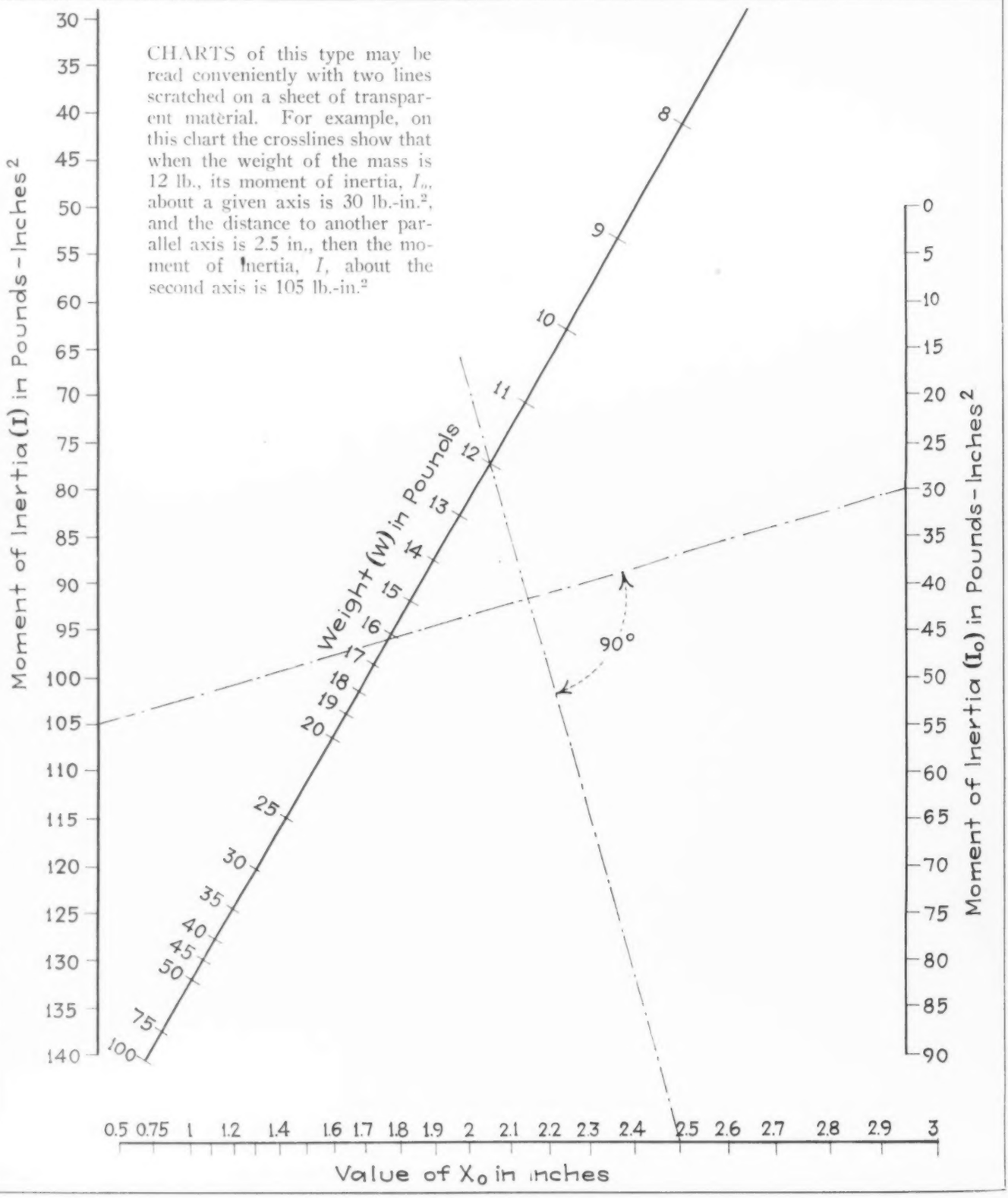
Chart for Transferring Moment of Inertia

CHARTS of this type may be read conveniently with two lines scratched on a sheet of transparent material. For example, on this chart the crosslines show that when the weight of the mass is 12 lb., its moment of inertia, I_o, about a given axis is 30 lb.-in.^{2}, and the distance to another parallel axis is 2.5 in., then the moment of inertia, I, about the second axis is 105 lb.-in.^{2}



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